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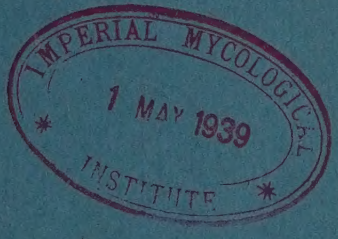

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MATHÉMATIQUES

SUR LES THÉORÈMES D'UNICITÉ POUR LES SURFACES FERMÉES

Par A. D. ALEXANDROFF

(Présenté par I. M. Vinogradow, de l'Académie, le 11. XII. 1938)

Démontrons le théorème suivant.

Théorème. *Soit* $Z(u_1, u_2, u_3)$ *une fonction définie dans tout l'espace* (u_1, u_2, u_3) *analytique et positivement homogène du premier degré* [*c'est-à-dire telle que pour* $r \geqslant 0$ *on a* $Z(ru_1, ru_2, ru_3) = rZ(u_1, u_2, u_3)$]. *Supposons que sa seconde différentielle ne possède un signe déterminé en aucun point* (u_1, u_2, u_3) (*c'est-à-dire en chaque point elle est ou bien une forme non-définie des différentielles* du_i, *ou bien elle est identiquement nulle*). *Alors* $Z(u_1, u_2, u_3)$ *est une fonction linéaire*:

$$Z(u_1, u_2, u_3) = a_1u_1 + a_2u_2 + a_3u_3.$$

Pour démontrer ce théorème interpretons les variables u_1, u_2, u_3 comme les composantes d'un vecteur $\bar{u}$ dans un système de coordonnées rectangulaires et considérons l'enveloppe Z de la famille des plans qui dans le système des coordonnées considéré sont déterminés par les équations

$$x_1u_1 + x_2u_2 + x_3u_3 = Z(u_1, u_2, u_3). \tag{1}$$

En vertu de ce que la fonction $Z(u_1, u_2, u_3)$ est positivement homogène du premier ordre, on peut se borner aux vecteurs unitaires $\bar{n}$, c'est-à-dire supposer que $\sqrt{u_1^2 + u_2^2 + u_3^2} = 1$, ce qui revient à l'étude de la fonction sur la sphère E de rayon 1 (les points sur la sphère E unitaire seront désignés par la même lettre que les vecteurs correspondants). On voit alors que la famille (1) dépend de deux paramètres et qu'au lieu de (1) on peut écrire dans les notations vectorielles

$$\bar{n}\,\bar{x} = Z(\bar{n}). \tag{2}$$

Les coordonnées des points de la surface Z seront

$$x_i = \frac{\partial Z(u_1, u_2, u_3)}{\partial u_i} \quad (i = 1, 2, 3). \tag{3}$$

Aux points où $d^2Z(u_1, u_2, u_3)$ ne s'annulle pas, la surface Z possède un plan tangent bien déterminé. Les valeurs caractéristiques de d^2Z sont les rayons de courbure principaux de la surface Z. Donc, aux points où d^2Z est une forme non-définie, la surface Z coupe son plan tangent [1].

D'ailleurs, la surface Z est bornée, donc elle a des plans d'appui dans toutes les directions. Ils peuvent être tangents à Z seulement aux points qui correspondent aux (u_1, u_2, u_3) pour lesquels $d^2Z\ (u_1, u_2, u_3)$ s'annulle identiquement, donc

$$\frac{\partial^2 Z}{\partial u_i \partial u_k} = 0 \quad (i, k = 1, 2, 3). \tag{4}$$

Désignons par N l'ensemble des points de la sphère N unitaire vérifiant les conditions (4). On a pour les ensembles de cette nature le lemme suivant.

Lemme I. *Soit N l'ensemble des points de la sphère unitaire E pour lesquels les fonctions analytiques $f_1(\bar{n}), \ldots, f_m(\bar{n})$ s'annullent simultanément. On peut alors affirmer que les cas suivants seulement sont possibles: 1) ou bien N est vide, 2) ou bien N coïncide avec toute la surface E, 3) ou bien N est formé d'un nombre fini de points, 4) ou bien N est formé de courbes qui divisent la surface en un nombre fini de domaines tels qu'à l'intérieur de chacun de ces domaines les fonctions $f_1(\bar{n}), \ldots, f_m(\bar{n})$ s'annullent simultanément en un nombre fini de points au plus.*

Ce lemme est une simple conséquence d'un théorème connu de Weierstrass sur les fonctions analytiques implicites (2).

Tout d'abord dans ce cas que nous considérons N n'est pas vide, car dans le cas contraire Z n'aurait pas de plans d'appui. Si N coïncide avec toute la surface E, la différentielle d^2Z s'annulle partout, donc $Z(u_1, u_2, u_3)$ est une fonction linéaire. Il reste donc à exclure les cas 3) et 4) indiqués dans le lemme I. À cet effet nous allons profiter du

Lemme II. *Si le point $\bar{n}_0$, où $d^2Z \equiv 0$, est un point isolé, ce n'est que le plan d'appui avec la normale $\bar{n}_0$ qui peut passer par le point $\bar{x}_0$ correspondant de la surface Z (la démonstration de ce lemme sera donnée dans la suite).*

Supposons que l'ensemble N est formé d'un nombre fini de points. Alors, comme les plans d'appui de Z ne peuvent exister qu'aux points correspondant aux points $\bar{n}$ de N, il suit du lemme II que la surface Z ne peut avoir qu'un nombre fini de plans d'appui. Mais ceci est en contradiction avec le fait que Z est bornée; donc, N ne peut être formé d'un nombre fini de points.

Il reste à considérer la quatrième possibilité du lemme I. Soit G un domaine sur E borné par une courbe L appartenant à l'ensemble N et tel que dans ce domaine $d^2Z \equiv 0$ en un nombre fini de points seulement.

Comme on a sur L l'égalité $d^2Z\ (\bar{u}) \equiv 0$, on voit que sur L

$$x_1 = \frac{\partial Z}{\partial u_1} = a_1, \quad x_2 = \frac{\partial Z}{\partial u_2} = a_2, \quad x_3 = \frac{\partial Z}{\partial u_3} = a_3 \tag{5}$$

sont constants. Mais en vertu de l'homogénéité de $Z\ (\bar{u})$, on a

$$Z(\bar{u}) = u_1 \frac{\partial Z}{\partial u_1} + u_2 \frac{\partial Z}{\partial u_2} + u_3 \frac{\partial Z}{\partial u_3}, \tag{6}$$

donc sur L

$$Z(\bar{u}) = a_1 u_1 + a_2 u_2 + a_3 u_3. \tag{7}$$

Définissons une fonction $Z^*\ (u_1, u_2, u_3)$ positivement homogène de premier degré, coïncidant aves $Z(u_1, u_2, u_3)$ sur G et égale à $a_1u_1 + a_2u_2 + a_3u_3$ à l'extérieur du domaine G.

Cette fonction a les deux premières dérivées continues, puisque sur la frontière du domaine G on a $d^2Z\ (\bar{u}) \equiv 0$.

Construisons la surface Z^*, enveloppe de la famille des plans

$$x_1u_1 + x_2u_2 + x_3u_3 = Z^*\ (u_1,\ u_2,\ u_3). \tag{8}$$

La surface Z^* possède les plans d'appui de toutes les directions. D'ailleurs, aux points $\bar{x}$ sur Z^*, qui correspondent aux points $\bar{n}$ du domaine G, il ne peut exister qu'un nombre fini de plans d'appui, ce qui résulte du lemme II.

Donc, tous les plans d'appui de Z^* passent par un seul point $(a_1,\ a_2,\ a_3)$ qui correspond aux valeurs $u_1,\ u_2,\ u_3$, pour lesquelles

$$Z^*(u_1,\ u_2,\ u_3) = a_1u_1 + a_2u_2 + a_3u_3. \tag{9}$$

[En vertu de (3) ou (5) les valeurs $a_1,\ a_2,\ a_3$ sont précisément les coordonnées du point de la surface Z^* qui correspond aux $u_1,\ u_2,\ u_3$ pour lesquels (9) est vérifié].

Mais alors Z^* se réduit au point $(a_1,\ a_2,\ a_3)$, donc le domaine G disparaît, car il doit correspondre à chacun de ses points $\bar{n}$, où $d^2Z^*(\bar{n}) \not\equiv 0$, un point de Z, où il existe un plan tangent à cette surface. Ainsi notre théorème est démontré.

Démontrons le lemme II. Soit $\bar{n}_0$ un point isolé où $d^2Z\ (\bar{n}_0) \equiv 0$. Soit $\bar{x}_0$ le point correspondant de la surface Z. Supposons, par impossible, qu'il existe au point $\bar{x}_0$ un plan d'appui P_1, ayant une normale $\bar{n}_1 \neq \bar{n}_0$. Soit U un voisinage de $\bar{n}_0$ qui ne contient ni à son intérieur ni sur sa frontière d'autres points, où l'on a $d^2Z(\bar{n}) \equiv 0$, et d'ailleurs assez petit pour qu'il ne coupe pas tous les grands cercles passant par $\bar{n}_1$. Soit V le voisinage correspondant du point $\bar{x}_0$ sur Z. En tous les points de V, sauf peut être au point $\bar{x}_0$, le plan tangent existe. Sur le plan P_1, la surface V n'a qu'un seul point $\bar{x}_0$, car dans le cas contraire P_1 ne serait pas un plan d'appui de V. Il existe donc des plans P, parallèles à P_1, et dont les intersections avec Z sont des courbes fermées L. Toutes les courbes L possèdent des tangents variant d'une manière continue et elles possèdent des droites d'appui dans toutes les directions, donc des normales de toutes les directions. Une normale à L est la projection sur P d'une normale à Z au même point. Donc, l'existence des normales de toutes les directions pour L prouve qu'il y a sur Z des points dont les représentations sphériques se trouvent sur tous les grands cercles passant par $\bar{n}_1$. Or, la représentation sphérique de V est le voisinage U choisi du point $\bar{n}_0$. Nous aboutissons à une contradiction en tenant compte du choix de U, et le lemme est ainsi démontré.

Le théorème que nous avons démontré peut encore être énoncé de la manière suivante: soient H_1 et H_2 des corps convexes ayant des fonctions d'appui analytiques. Si les indicatrices de Dupin sur H_1 et H_2 aux points, où les normales sont parallèles, ne peuvent être placées l'une dans l'autre quand on met ces points en coïncidence en effectuant une translation parallèle, alors les corps H_1 et H_2 sont égaux et situés parallèlement. Il devient alors évident que le théorème démontré dans cette Note est analogue au théorème suivant sur les polyèdres que j'ai démontré antérieurement [3]. Si pour deux polyèdres convexes les faces ayant des normales extérieures parallèles ne peuvent être placées l'une dans l'autre au moyen d'une translation parallèle, alors ces polyèdres

sont égaux et parallèlement disposés (il correspond toujours à une face d'un polyèdre une face de l'autre polyèdre avec la même normale extérieure; mais cette face peut dégénérer en une arête ou un sommet).

En prenant pour base le théorème qui vient d'être démontré, on obtient un théorème général sur l'unicité des surfaces fermées que j'ai démontré récemment [4] [plus précisément, le théorème qui suit ne coïncide pas totalement avec celui que j'ai démontré dans la Note citée: en effet, nous exigeons maintenant que la fonction d'appui soit analytique, tandis que là nous n'avons supposé que l'analyticité par morceaux; au contraire, la fonction $f(R_1, R_2; \bar{n})$ est ici quelconque].

Théorème. *Soit $f(R_1, R_2; \bar{n})$ une fonction du point $\bar{n}$ sur la sphère unitaire et des variables R_1 et R_2 variant dans le domaine $R_1 \geqslant R_2$. Supposons que pour chaque $\bar{n}$ cette fonction de R_1 et R_2 soit monotone (non constante). Une surface H dont la représentation sphérique couvre une fois toute la sphère et qui possède une fonction d'appui analytique est déterminée d'une manière unique, abstraction faite des translations, quand on donne les valeurs de la fonction $f(R_1, R_2; \bar{n})$ pour toutes les normales $\bar{n}$, où R_1 et R_2 sont les rayons principaux de courbure de la surface H au point, où sa normale est $\bar{n}$.*

Soient $H'(\bar{u})$, $H''(\bar{u})$ les fonctions d'appui de deux surfaces pour lesquelles

$$f(R_1', R_2'; \bar{n}) = f(R_1'', R_2''; \bar{n}). \tag{10}$$

Comme $f(R_1, R_2; \bar{n})$ est monotone, il en résulte que $R_1' - R_1''$ et $R_2' - R_2''$ sont de signes contraires ou bien s'annullent simultanément. Donc, $d^2[H'(\bar{u}) - H''(\bar{u})]$ est ou bien une forme non-définie ou bien elle est identiquement nulle. Donc, en vertu du théorème démontré, $H'(\bar{u}) - H''(\bar{u})$ est une fonction linéaire, donc, les surfaces H' et H'' sont égales et parallèles.

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MATHÉMATIQUES

SUR LE NORMALISATEUR D'UN ÉLÉMENT DANS UN GROUPE FINI

Par P. E. DUBUQUE

(Présenté par O. J. Schmidt, de l'Académie, le 14. XII. 1938)

Le but de la présente Note est de démontrer quelques théorèmes sur les normalisateurs des éléments d'un groupe fini. On utilise les méthodes de la théorie des quasi-normalisateurs construite par W. Turkin (1), ainsi que certaines méthodes nouvelles. L'application de quelques théorèmes sur le normalisateur permet d'obtenir un nouveau critère pour les groupes finis non-simples. Indiquons d'abord la proposition générale suivante contenant comme cas particuliers et ayant pour conséquences plusieurs résultats de la suite.

Théorème 1. *Soit A un élément d'ordre p^k d'un groupe $\mathfrak{G}$ (p étant un nombre premier impair). Si chaque élément du $(k-i-1)$-ième quasi-normalisateur $\mathfrak{N}_{A^{p^i}}^{(k-i-1)}$ de l'élément A^{p^i} conjugué à A^z est de la forme A^{mz}, où $m \equiv 1 \pmod p$, le rapport des ordres des normalisateurs des éléments $A^{p^{i+1}}$ et A^{p^i} n'est pas divisible par p^2.*

Indiquons quelques points essentiels de la démonstration du théorème. Le symbole λ_i aura le sens qui lui a été donné par W. K. Turkin dans son article «Quasi-normalisateurs et représentations monomiales». Pour le cas où $\lambda_i \neq k-i$ la démonstration est basée sur la proposition auxiliaire suivante.

Lemme. *Dans les conditions du théorème 1, si $\lambda_i \neq k-i$, le rapport des ordres des quasi-normalisateurs $\mathfrak{N}_{A^{p^i}}^{(\lambda_i)}$ et $\mathfrak{N}_{A^{p^{i+1}}}^{(\lambda_i)}$ est congru à 1 par rapport au module p^{i+1}.*

La démonstration du lemme cité est assez compliquée; elle est basée sur le fait qu'une expression, souvent utilisée dans la théorie des représentations monomiales d'un groupe, est invariante.

Pour le cas $\lambda_i \neq k-1$ le théorème 1 suit immédiatement du lemme cité. En effet, d'après la propriété fondamentale des quasi-normalisateurs, le rapport des ordres des groupes $\mathfrak{N}_{A^{p^{i+1}}}^{(\lambda_i)}$ et $\mathfrak{N}_{A^{p^i}}^{(\lambda_i)}$ est égal au rapport des ordres des groupes $\mathfrak{N}_{A^{p^{i+1}}}^{(k-i-1)}$ et $\mathfrak{N}_{A^{p^i}}^{(k-i-1)}$. Donc, ce dernier rapport n'est pas divisible par p. D'autre part, le normalisateur $\mathfrak{N}_{A^{p^i}}^{(k-i)}$ de l'élément A^{p^i} est un sous-groupe d'indice p du groupe $\mathfrak{N}_{A^{p^i}}^{(k-i-1)}$. Dans le cas où $\lambda_i = k-i$ on considère le développement

$$\mathfrak{N}_{A^{p^{i+1}}}^{(k-i-1)} = \mathfrak{N}_{A^{p^i}}^{(k-i)} + \mathfrak{N}_{A^{p^i}}^{(k-i)} N_2'' + \ldots + \mathfrak{N}_{A^{p^i}}^{(k-i)} N_f'' \qquad (1)$$

et on démontre que les systèmes

$$\mathfrak{N}_{A^{p^i}}^{(k-i)} N_r', \ \mathfrak{N}_{A^{p^i}}^{(k-i)} N_r'', \ A, \ \ldots, \ \mathfrak{N}_{A^{p^i}}^{(k-i)} N_r'' A^{p^{i+1}-1} \qquad (2)$$

(où N_r' est un résidu quelconque du développement (1) qui n'est pas égal à 1) sont différents. Tous les systèmes du développement (1) sauf le système $\mathfrak{N}_{A^{p^i}}^{(k-i)}$ peuvent être groupés d'une manière analogue à (2). Il en résulte que pour le cas ($\lambda_i = k-i$) le rapport des ordres des normalisateurs des éléments $A^{p^{i+1}}$ et A^{p^i} est congru à 1 par rapport au module p^{i+1}.

Comme conséquences immédiates du théorème 1 on obtient les résultats suivants.

Théorème 2. *Soit A un élément d'ordre p^k du groupe $\mathfrak{G}$ (p étant un nombre premier impair). Si chaque élément du normalisateur de l'élément $A^{p^{i+1}}$ conjugué à A^z est de la forme A^{mz}, où $m \equiv 1 \pmod p$, alors le rapport des ordres des normalisateurs des éléments $A^{p^{i+1}}$ et A^{p^i} n'est pas divisible par p^2.*

Théorème 3. *Soit A un élément d'ordre p^k du groupe $\mathfrak{G}$ (p étant un nombre premier impair). Si chaque élément du normalisateur d'un groupe cyclique $\{A^{p^i}\}$ conjugué à A^z est de la forme A^{mz}, où $m \equiv 1 \pmod p$, alors le rapport des ordres des normalisateurs des éléments $A^{p^{i+1}}$ et A^{p^i} n'est pas divisible par p^2.*

En appliquant successivement un nombre suffisant de fois les théorèmes 1, 2 et 3, on peut obtenir les résultats suivants.

Théorème 4. *Soit A un élément d'ordre p^k du groupe $\mathfrak{G}$ (p étant un nombre premier impair). Si chaque élément du $(k-i-1)$-ième quasi-normalisateur $\mathfrak{N}_{A^{p^i}}^{(k-i-1)}$ de l'élément A^{p^i} conjugué à l'élément A^z est de la forme A^{mz}, où $m \equiv 1 \pmod p$, alors le rapport des ordres des normalisateurs des éléments $A^{p^{i+1}}$ et A n'est pas divisible par p^{i+2}.*

Théorème 5. *Soit A un élément d'ordre p^k du groupe $\mathfrak{G}$ (p étant un nombre premier impair). Si chaque élément du normalisateur de l'élément $A^{p^{i+1}}$ conjugué à A^z est de la forme A^{mz}, où $m \equiv 1 \pmod p$, alors le rapport des ordres des normalisateurs des éléments $A^{p^{i+1}}$ et A n'est pas divisible par p^{i+2}.*

Théorème 6. *Soit A un élément d'ordre p^k du groupe $\mathfrak{G}$ (p étant un nombre premier impair). Si chaque élément du normalisateur du groupe cyclique $\{A^{p^i}\}$ conjugué à A^z est de la forme A^{mz}, où $m \equiv 1 \pmod p$, alors le rapport des ordres des normalisateurs des éléments $A^{p^{i+1}}$ et A n'est pas divisible par p^{i+2}.*

Si le normalisateur de l'élément A^{p^i} coïncide avec le normalisateur de l'élément A, on peut préciser le théorème 2 en démontrant la proposition suivante.

Théorème 7. *Soit A un élément d'ordre p^k (p étant un nombre premier impair) d'un groupe $\mathfrak{G}$. Si le normalisateur de l'élément A^{p^i} ($i \neq 0$) coïncide avec le normalisateur de l'élément A et chaque élément de ce normalisateur conjugué à A^z est de la forme A^{mz}, où $m \equiv 1 \pmod p$, alors le rapport des ordres des normalisateurs des éléments $A^{p^{i+1}}$ et A est congru à 1 par rapport au module p^{i+1}.*

Pour démontrer ce théorème on fait les remarques suivantes: 1) il suit des conditions du théorème que l'on a $\mathfrak{N}_{A^{p^{i-1}}}^{(1)} = \mathfrak{N}_{A^{p^{i-1}}}^{(2)} = \ldots = \mathfrak{N}_{A^{p^{i-1}}}^{(k-i+1)}$, donc $\lambda_{i-1} = k-i+1$; 2) en appliquant les mêmes méthodes de calcul que dans le théorème 1, on obtient l'égalité $\mathfrak{N}_{A^{p^i}}^{(1)} = \mathfrak{N}_{A^{p^i}}^{(2)} = \ldots = \mathfrak{N}_{A^{p^i}}^{(k-i)}$, donc $\lambda_i = k-i$. Il reste ensuite de répéter la démonstration du théorème 1 pour le cas $\lambda_i = k-i$.

Les théorèmes 1—7 restent encore vrais pour le cas où $p=2$, si l'on

introduit la condition supplémentaire suivante: l'élément du quatrième ordre $A^{p^{k-2}}$ n'est pas conjugué à son élément inverse [voir à ce sujet l'article de l'auteur «Sur l'ordre d'un élément dans un groupe simple» (3)]. Par exemple, pour le cas $p=2$ le théorème 1 obtient la forme suivante.

Théorème 8. *Soit A un élément d'ordre 2^k du groupe $\mathfrak{G}$. Si chaque élément du $(k-i-1)$-ième quasi-normalisateur $\mathfrak{N}_{A^{2^i}}^{(k-i-1)}$ de l'élément A^{2^i} conjugué à une puissance de A est encore une puissance de A et si l'élément $A^{2^{k-2}}$ n'est pas conjugué à son élément inverse, le rapport des ordres des normalisateurs des éléments $A^{2^{i+1}}$ et A^{2^i} n'est pas divisible par 4.*

D'une manière tout à fait analogue on change les énoncés des théorèmes 2—7 pour le cas où $p=2$. Indiquons seulement le changement d'un cas particulier du théorème 4 ($i=k-2$) pour $p=2$.

Théorème 9. *Soit A un élément d'ordre 2^k d'un groupe $\mathfrak{G}$. Si chaque élément du normalisateur de l'élément $A^{2^{k-2}}$ conjugué à une puissance de A est encore une puissance de A et si l'élément $A^{2^{k-2}}$ n'est pas conjugué à son élément inverse, le rapport des ordres des normalisateurs des éléments $A^{2^{k-1}}$ et A n'est pas divisible par 2^{k-1}.*

Les théorèmes énoncés permettent d'obtenir le critère suivant pour qu'un groupe soit non-simple.

Théorème 10. *Soit A un élément d'ordre p^k d'un groupe $\mathfrak{G}$ (p étant un nombre premier impair). Supposons que chaque élément du normalisateur de l'élément $A^{p^{k-1}}$ conjugué à A^z est de la forme A^{mz}, où $m\equiv 1 \pmod p$. Si le normalisateur de l'élément A est un groupe abélien, le groupe $\mathfrak{G}$ possède un diviseur normal. L'ordre de ce diviseur normal est un multiple de n, si l'on désigne par $p^\beta n$ l'ordre du groupe $\mathfrak{G}$, et premier avec p.*

Pour démontrer le théorème 10 il suffit d'appliquer le théorème 5 et le critère suivant pour les groupes non-simples introduit dans l'article de P. Dubuque et W. Turkin «Sur la structure des groupes simples» [une communication préliminaire a été publiée en 1938 (4)].

Soit $\mathfrak{P}$ un sous-groupe abélien d'ordre p^α d'un certain groupe $\mathfrak{G}$ d'ordre $p^\beta n$ (p est un nombre premier impair, n n'est pas divisible par p). Soit A un élément d'ordre p^k du sous-groupe $\mathfrak{P}$; on suppose d'ailleurs que chaque élément $\mathfrak{P}$ conjugué à A^z est de la forme A^{mz}, où $m\equiv 1 \pmod p$. Si l'ordre du normalisateur de l'élément $A^{p^{k-1}}$ n'est pas divisible par $p^{\alpha+k}$, le groupe $\mathfrak{G}$ possède un diviseur normal d'ordre non divisible par n.

Dans l'énoncé du théorème 10 le normalisateur de l'élément $A^{p^{k-1}}$ peut être remplacé par le normalisateur du groupe cyclique $\{A^{p^{k-2}}\}$ ou bien par le premier quasi-normalisateur de l'élément $A^{p^{k-2}}$. D'autre part, au lieu d'exiger dans les conditions du théorème 10 que le normalisateur de l'élément A soit commutatif, on peut imposer une condition moins restrictive en supposant que le p sous-groupe de Syloff du normalisateur de l'élément A soit commutatif.

Indiquons un cas particulier du théorème 10.

Théorème 11. *Soit A un élément d'ordre p^k d'un groupe $\mathfrak{G}$ d'ordre $p^\beta n$ [p étant un nombre premier impair, n étant premier avec $p(p-1)$]. Supposons que chaque élément du normalisateur de l'élément $A^{p^{k-1}}$ conjugué à une puissance de A est encore une puissance de A. Si le normalisateur de l'élément A est un groupe abélien, le groupe $\mathfrak{G}$ possède un diviseur normal dont l'ordre est un multiple de n.*

Pour le cas $p=2$ ou peut obtenir le résultat suivant.

Théorème 12. *Soit A un élément d'ordre 2^k d'un groupe $\mathfrak{G}$ d'ordre $2^\beta n$ (n étant impair). Supposons que chaque élément du normalisateur de l'élément $A^{2^{k-2}}$ conjugué à une puissance de A est encore une puissance de A et que l'élément $A^{2^{k-2}}$ n'est pas conjugué à son élément inverse. Alors, si le normalisateur de l'élément A est un groupe abélien, le groupe $\mathfrak{G}$ possède un diviseur normal dont l'ordre est un multiple de n.*

Pour démontrer le théorème 12 il suffit d'appliquer le théorème 9 et le critère suivant pour les groupes non-simples, démontré dans l'article cité (4). Soit $\mathfrak{P}$ un sous-groupe abélien d'ordre 2^α d'un certain groupe $\mathfrak{G}$ d'ordre $2^\beta n$ (n étant impair). Soit A un élément d'ordre 2^k du sous-groupe $\mathfrak{P}$ et supposons d'ailleurs que chaque élément du groupe $\mathfrak{P}$ conjugué à une puissance de A est encore une puissance de A. Si l'élément $A^{2^{k-2}}$ n'est pas conjugué à son élément inverse et si l'ordre du normalisateur de l'élément $A^{2^{k-1}}$ n'est pas divisible par $2^{k+\alpha}$, le groupe $\mathfrak{G}$ possède un diviseur normal dont l'ordre est un multiple de n.

De même que dans le théorème 10, au lieu de supposer que le normalisateur de l'élément A est commutatif, on peut dans le théorème 12 imposer une condition moins restrictive, à savoir que le sous-groupe de Syloff de ce normalisateur dont l'ordre est une puissance de 2 soit commutatif.

Remarquons que dans le cas où $k=1$ on peut dans les conditions du théorème 12 remplacer le normalisateur de l'élément $A^{2^{k-2}}$ par le normalisateur de l'élément $A^{2^{k-1}}$. Dans ce cas ($k=1$) on ne doit plus exiger que l'élément $A^{2^{k-2}}$ ne soit pas conjugué avec son élément inverse; cela résulte des remarques faites dans le travail cité (4).

En appliquant le théorème 10 au cas special $k=1$ et en tenant compte des remarques faites à propos du théorème 12, nous arrivons au résultat suivant.

Théorème 13. *Soit A un élément d'ordre p d'un groupe $\mathfrak{G}$ (p étant un nombre premier). Si le p sous-groupe de Syloff du normalisateur de l'élément A est un groupe abélien et si aucun de ses éléments n'est conjugué à A, le groupe $\mathfrak{G}$ possède un diviseur normal. L'ordre de ce diviseur normal est un multiple de n, si l'on désigne par $p^\beta n$ l'ordre du groupe $\mathfrak{G}$ (n n'est pas divisible par p).*

Pour démontrer le théorème 13 il suffit de remarquer que pour p impair il est un cas particulier du théorème 10. En effet, si l'élément A n'est conjugué à aucun élément d'un certain p sous-groupe de Syloff de son normalisateur, il ne peut être conjugué à aucun élément de son normalisateur. Pour le cas $p=2$ on voit que le théorème est vrai si l'on tient compte du théorème 12 et des remarques, faites à propos de ce théorème. Le théorème 13, en ce qui concerne l'existence du diviseur normal et non pas son ordre, présente une généralisation d'une proposition connue de Burnside (5). En concluant, remarquons que le théorème 13 peut aussi être obtenu comme une conséquence immédiate des théorèmes démontrés dans l'article cité (4).

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CHEMISTRY

A MIXED DICHLORO-DIAMMINE-PLATINUM POSSESSING A CIS-CONFIGURATION

By ANNA GELMAN

(Communicated by N. S. Kurnakov, Member of the Academy, 7. XII. 1938)

During an investigation of platinum ethylene dichlorides (1), we established that the preparation of stereo-isomers depends in this case upon the order in which neutral «substitutes» are introduced into the chloroplatinite molecule; that is, upon the action of ethylene on Kossa's salt, $Me(PtNH_3Cl_3)$, a cis-form is obtained, while upon the action of ammonia or pyridine on Zeise's salt, $Me(PtC_2H_4Cl_3)$, a trans-configuration is formed.

At that time we advanced the assumption that this method of preparation of stereo-isomers is apparently applicable only in those cases when one of the neutral substitutes is active, i. e. possesses a greater trans-effect.

To prove the correctness of this assumption it was necessary to carry out a similar investigation under the condition when both neutral substitutes will possess an approximately equal trans-activity. It was natural to select ammonia and pyridine as such substitutes, since their behaviour during co-ordination addition is well known.

One may expect on the basis of the regularity of the trans-effect (2) that, during the action of pyridine on the ammonium Kossa's salt, the reaction will proceed according to the equation:

$$Me\begin{bmatrix} NH_3 & & Cl \\ & Pt & \\ Cl & & Cl \end{bmatrix} + Py \rightarrow \begin{bmatrix} NH_3 & & Cl \\ & Pt & \\ Py & & Cl \end{bmatrix} + MeCl$$

while during the action of ammonia on the pyridine Kossa's salt, according to the equation:

$$Me\begin{bmatrix} Py & & Cl \\ & Pt & \\ Cl & & Cl \end{bmatrix} + NH_3 \rightarrow \begin{bmatrix} NH_3 & & Cl \\ & Pt & \\ Py & & Cl \end{bmatrix} + MeCl.$$

As a result, the same substance $[NH_3ClPyClPt]$—a mixed dichloro-diammine-platinum possessing a cis-form, should be formed in both cases. We did not find any references in the literature which point to the existence of this compound (Classon's attempt to obtain it, as is known, was not successful).

Experimental verification of the above considerations would definitely decide the question as to the greater trans-activity of ethylene hydrocarbons.

Experimental Part. 1.1 g of pyridine were added in the cold to 5 g of the ammonium Kossa's salt dissolved in 20 cm^3 of water. After some 15—20 minutes the solution became noticeably turbid, and on further stand-

ing a yellow precipitate began to separate. After one day the precipitate formed a consistent, sticky mass.

Upon prolonged trituration with a glass rod the sticky mass changed to small yellow crystals which, when examined under the microscope, appeared to be completely uniform. The preparation of the substance was repeated three times with the same result. After filtering, the precipitate was first washed with water and then with alcohol, and was dried to constant weight. The weight of the dry substance was 4.6 g. That the substance obtained actually has the composition $[PtNH_3ClPyCl]$, was confirmed by an analysis, the results of which are presented below (in %):

Obtained	Pt —53.84
Calculated	Pt —53.90
Obtained	Cl_2—19.42
Calculated	Cl_2—19.58

Upon dissolving the substance in ammonia on a water-bath, the following reaction occurred:

$$[NH_3ClPyClPt]+2NH_3 \rightarrow [(NH_3)_3PyPt]\ Cl_2.$$

As a result of this reaction a completely white, crystalline substance was obtained which is readily soluble in water. (Found: platinum—49.58 and 48.99%; calculated 49.28%. Found: Cl_2—17.97%; calculated 17.90%).

The above tetrammine upon reacting with chloroplatinite forms a crystalline precipitate having a raspberry colour.

Upon dissolving $[PyClNH_3ClPt]$ in thiourea, the reaction proceeds according to the following equation:

$$[PyClNH_3ClPt] + 4SC(NH_2)_2 \rightarrow Pt4SC(NH_2)_2Cl_2 + Py + NH_3.$$

During this a characteristic dichloro-tetrathiourea-platinum separates in the form of yellow, shiny needles.

The aqueous solution of $Pt4SC(NH_2)_2Cl_2$ was precipitated with potassium chloroplatinite. The substance obtained contained 46.47% of platinum. For $[Pt4SC(NH_2]_2\ PtCl_4$, the calculated platinum content is 46.68%.

The following reaction, described by A. M. Rubinstein (3), proceeded very smoothly:

$$[PtPyClNH_3Cl]+Cl_2 \rightarrow [PtPyClNH_3ClCl_2] \quad (1)$$

$$[PtPyClNH_3ClCl_2]+Py \rightarrow [PtPyClPyClCl_2]+NH_3. \quad (2)$$

The yellow, finely crystalline substance which separated out contained 39.71% of platinum. Calculated, assuming it to be $[Pt(PyCl)_2Cl_2]$, there should be 39.43% of platinum.

On the basis of the two latter reactions—Kurnakov's reaction and Rubinstein's reaction—one may affirm that the dichloro-diammine-platinum obtained and studied by us possesses a cis-configuration.

The solubility of $[PyClNH_3ClPt]$ in water at 25°C is 0.50 g in 100 cm^3. The molecular conductance of its aqueous solution was determined by M. M. Iakshin (Table 1).

Table 1

Molecular Electrical Conductance of $[PyClNH_3ClPt]$ at 25° C

v	1 000	2 000	4 000	8 000
i	15	28	40	48
μ_v	5.47	8.51	12.8	15.9

As should have been expected, the substance was found to be a non-electrolyte.

The pyridine Kossa's salt was prepared by boiling an aqueous solution of K_2PtCl_4 with PyHCl for 3—4 hours. The reaction proceeded very smoothly. A small quantity of dichloro-dipyridine-platinum with an admixture of some substance having a green colour was readily separated upon filtering the cooled solution.

After concentrating the filtrate on a water-bath, fine orange crystals separated upon cooling. Found: Pt = 44.72%, Cl_2 = 24.43%. Calculated for the compound $K(PtPyCl_3)\cdot H_2O$: Pt = 44.60%, Cl_2 = 24.32%.

20 cm³ of H_2O and 1 cm³ of ammonia were added in the cold to 5 g of $K[PtPyCl_3]\cdot H_2O$. In a few minutes after the ammonia was added, the solution became slightly turbid, and then a small precipitate started to form gradually. The next day the precipitate was filtered off, and some ammonia (0.5 cm³) was once more added to the filtrate. After this another small amount of the precipitate fell out.

With respect to its outer appearance and in accordance with analysis, the substance appears to be completely identical to the dichloride formed by starting with the ammonia Kossa's salt. Found: Pt = 53.78%; Cl_2 = 20.09%. Calculated for the compound $[PtNH_3ClPyCl]$: Pt = 53.90%; Cl_2 = 19.58%.

This conclusion was also verified upon an investigation of its properties: with thiourea the substance formed a chloride having the composition $Pt4SC(NH_2)_2Cl_2$. Rubinstein's reaction (l. c.) proceeded just as smoothly as in the first case. The solubility of the salt in water at 25° C is 0.48 g in 100 cm³. The solubility of a mixture of the salts taken in equal amounts is 0.48 g in 100 cm³.

The molecular electrical conductance of the salt obtained is presented in Table 2.

Table 2

Molecular Electrical Conductance of $[PtNH_3ClPyCl]$ at 25° C

v	1 000	2 000
t	30	40
μ_v	7.42	13.4

In other words, we obtained an electrical conductance of the same order as that in the first case. Consequently, both analysis and comparison of the basic properties of these two substances confirm their complete identity.

In concluding the experimental part, it is interesting to compare some properties of the trans- and cis-form of the compound $[PtPyClNH_3Cl]$.

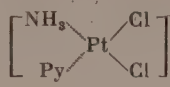
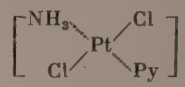
The trans-form was obtained according to Jörgensen (4), by dissolving $Pt(PyCl)_2$ in ammonia and consequently splitting with hydrochloric acid. Table 3 shows how the isomers differ in their properties.

The optical constants were determined by M. N. Lashenko in the Crystallographic laboratory of the Institute of General and Inorganic Chemistry of the Academy of Sciences of the USSR.

Crystals of $[PtPyNH_3Cl_2]$ possessing a trans-configuration have the form of flattened needles. They belong to the triclinic system. Their optical constants are: $N_g > 1.790$; $N_m = 1.732$; $N_p = 1.653$. The crystals are optically negative, $2V = 80°$.

Crystals $[PtPyClNH_3Cl]$ possessing a cis-configuration have the shape of lamellae or scales, are badly formed, and therefore the system to which they belong could not be determined. Their optical constants are: $N_g > 1.790$; $N_m = 1.732$; $N_p = 1.624$. The angle of the optical axes is large and its sign could not be determined.

Table 3

Property	Cis-isomer 	Trans-isomer 
Colour	Yellow	Greenish-yellow
Solubility in water at 25° C	0.48 g in 100 cm³	0.035 g in 100 cm³
Electrical conductance of an aqueous solution at 25° C	v=1 000 2 000 4 000 i= 15 28 40 μ_v= 5.47 8.51 12.8	Due to its slight solubility the electrical conductance could not be determined
The effect of $AgNO_3$ in the cold	Weak opalescence	Weak opalescence
The effect of $SC(NH_2)_2$	Dissolves forming $[Pt4SC(NH_2)_2]Cl_2$	Dissolves forming $[Pt2SC(NH_2)_2PyNH_3]Cl_2$

We believe that the object which we had in mind when the present investigation was undertaken has been achieved. Changing the order of the introduction of ammonia and pyridine into the chloroplatinite molecule, we obtained a substance which was identical both in composition and in properties, i. e. a mixed cis-dichloro-diammine-platinum, $[PtNH_3ClPyCl]$.

Consequently, the preparation of geometric isomers, depending upon the order of the introduction of neutral substitutes into the molecule, is possible only in those cases when one of the neutral substitutes possesses an enhanced trans-effect, as for example ethylene hydrocarbons, carbon monoxide, and similar unsaturated molecules.

However, in the case when one is working with molecules possessing an equally small trans-activity, only the classical methods of preparing the stereo-isomers are applicable.

It seems to us that the question concerning the enhanced trans-activity of ethylene and of its homologues, and also of carbon monoxide, has been definitely settled as a result of the present investigation.

Summary

1. Upon the action of ammonia on $Me[C_5H_5NCl_3Pt]$ and upon the action of pyridine on $Me[NH_3Cl_3Pt]$, a substance possessing a cis-configuration is obtained whose composition is $[PtNH_3ClC_5H_5NCl]$.

2. The preparation of geometric isomers by means of the definite order of introduction of neutral substitutes is possible only when one of these substitutes possesses an enhanced trans-activity.

3. Ethylene hydrocarbons and unsaturated molecules in general exhibit an enhanced trans-effect, during co-ordination addition, caused by the peculiar character of the bond between these molecules and the central atom.

This investigation is being continued.

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CHEMISTRY

DETONATION IN AIR-MIXTURES OF PENTANE AND HEXANE IN TUBES

By K. I. SHTSHOLKIN

(Communicated by N. N. Semenov, Member of the Academy, 13.XII.1938)

It has been the object of the present research to ascertain whether in a tube filled with an air-mixture of pentane and hexane the ignition of a spark would induce a detonation.

For this purpose, mixtures were taken at an initial pressure ranging between 1 and 10 kg/cm² at temperatures varying from 20 to 500° C.

Experimental Arrangement. Mixtures of pentane or hexane with air at pressures above 2.5—3 atmospheres are known to be subject to spontaneous ignition, as soon as the temperature exceeds 280—300° C. An apparatus is therefore required where the whole experiment could be conducted in a time-interval less than the delay preceding the inflammation of the given mixture. The above condition has been satisfied by devising a special automatic apparatus.

By means of a high-speed valve provided with a spring the preliminarily mixed gases were transferred from the autoclave into a glass tube ($d = 16$ mm, $L \sim 110$ cm) through a short 10 mm wide connecting tube. Immediately after the admission of the mixture, the glass tube was closed by an electromagnetic back-valve provided at the entrance. The lever of the admission valve was connected with special movable ignition contacts, so that the ignition of the mixture could be started automatically at the required moment. The whole process of the admission of the mixture into the tube and the closing of the back-valve took about 0.02—0.03 sec. The glass tube was placed in a furnace which could be heated up to 600 °C and was provided with a longitudinal slit for photographing purposes. During a normal regime the temperature of the furnace could be maintained constant within 2—3° C by means of a special thermoregulator. The end of the tube was filled with glass wool in order to prevent the mixture from spontaneous ignition which might be provoked by shocks during its admission into the tube. A membrane indicator with optical registration was used to record the pressure, the time of admission and the moment of ignition. The ignition was produced by a 0.02 μF condenser discharge over a 0.2 mm wide gap between iron electrodes.

Experimental Results. A series of preliminary experiments was conducted with pentane-air mixtures ($\alpha = 1$ and 0.9) at pressures up to 11 kg/cm² at room temperature. Increase of pressure did not affect the propagation of the flame, and no traces of detonation could be detected.

Fig. 1 shows the results of experiments carried out with pentane-hexane mixtures at higher temperatures ($45\% C_5H_{12} + 55\% C_6H_{14}$). In all the cases α was equal to 0.9. The points in Fig. 1 refer to those states of the mixture when the propagation of the flame does not essentially differ from that at room temperature. In this case the velocity of the flame diminished towards the end of the tube. The asterisks refer to those states of the mixture when the propagation of the flame from the spark is accompanied by vibrations of the flame. For any given pressure, the amplitude of the vibrations and the

luminosity of the flame increased with increasing temperature until the phenomenon became considerably suppressed by the spontaneous ignition arising near the end of the tube. In no case was it possible to get film-records of the flame front at the beginning of the propagation.

The deflections and vibrations of the flame are evidently due to compression waves arising in the tube. The velocity of the waves, as calculated from the frequency of the vibrations, attained 1100 m/sec. The circles in Fig. 1 refer to those states when the ignition of a spark induced a detonation. In order to obtain detonation under the above conditions, the mixture has to be ignited at such a moment that

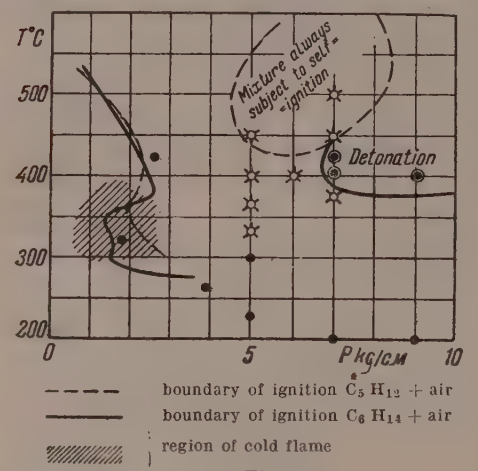

Fig. 1.

Fig. 2.

the gases at the end of the tube have no time to undergo spontaneous ignition. Whenever the ignition of the spark was late, the detonation became suppressed by the process of spontaneous ignition. In this case the propagation of the flame did not differ from that corresponding to the state marked by asterisks. At high temperatures it was impossible to avoid spontaneous ignition, and all attempts to obtain detonation failed. In mixtures of pentane and air there also took place a vibrational propagation, though at differing temperatures and pressures. But no detonation could be detected. In pentane-hexane mixtures the detonation arises near the end of the tube along the last 10 cm. Upon increasing the pressure from 7 to 9 kg/cm², the starting point of the detonation did not come any nearer to the spark.

Fig. 2 shows a photo of the detonation on a moving film. A retonation wave also arises at the place where the detonation starts, travelling in the opposite direction. The two waves are seen to start from the same point at obtuse angle characteristic of the phenomenon. The film track of the retonation wave appears very distinct and pronounced. In a mixture of 45% pentane and 55% hexane ($\alpha=0.9$) at $P_0=9$ kg/cm² and $T_0=405°$ C the detonation wave travels with a velocity of 1900 m/sec., the retonation wave—with a velocity of 1600 m/sec. Since the detonation starts near the end of the tube, these velocities cannot be determined very accurately, the error attaining as much as 10—15%. In no cases when detonation took place, the front of the flame could be recorded during the predetonation period. Nothing can therefore be said as to propagation of the flame during this period. From the moment of ignition to the onset of detonation the flame travels with an average velocity of 150 m/sec., if $P_0=7$ kg/cm² and $T_0=420°$ C.

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GEOCHEMISTRY

ON ISOMORPHIC SUBSTITUTIONS IN APATITE

By I. D. BORNEMAN-STARINKEVITCH

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In these recent years many investigators have been concerned with the study of isomorphic substitutions in apatite, which are especially interesting on account of their number being extremely high in this mineral. The variety of isomorphic substitutions in apatite is due, on the one hand, to the peculiar nature of its complex anion, which in a normal apatite consists of phosphorous and halogen ions partly substituted and partly combined in a complex with the ions of sulphur, silicon, carbon and oxygen; on the other hand, to the fact that its «normal» cation—calcium—can be replaced by elements of very different valency, such as monovalent sodium and trivalent cerium. The question arises therefore how to conciliate all the different substitutions and to unite them into a harmonious system without disturbing the strict regularity both in the arrangement of atoms in space and in the relation between the elements of chemical compounds which build up the crystal.

There are two quite different views concerning the question of what should be understood under a n i o n and c a t i o n, and which are the elements able to play the part of either of them in a crystalline chemical compound.

According to Goldschmidt (1), silicates are ionic lattices, whose anions are composed either of silicon-oxygen complexes, or of aluminium-silicon-oxygen complexes. Any electro-positive element may be a c a t i o n.

According to McConnell (2), the c a t i o n is an ion migrating to the cathode in the course of electrolysis, and the term «cation» has no meaning in the study of atoms (or ions) within the crystalline lattice; this conception enables to refer carbon to the substitutes of such a typical cation as calcium.

It is only by disregarding the chemical nature of the compound within the crystalline lattice that the definition of the cation as nothing but an ion migrating in the course of electrolysis becomes possible. Yet we know that the lattice is essentially determined by the charges of ions and ion complexes; in its definite places we find definite constituents of the chemical compound (ions) arranged in strict correspondence with the chemical bonds and relations characteristic of this compound. Every crystal (leaving out of the question the existence in it of individual molecules) is a chemical compound or a number of such, and the term «cation» has therefore doubtlessly a fundamental meaning in the study of atoms (and ions) within the crystalline lattice. But there is, indeed, a series of amphoteric elements which may play the part either of a cation or, when forming a covalent compound with oxygen, that of a complex anion. Carbon and nitrogen do not belong to them, and if they could be supposed

able to replace calcium spatially (5), nevertheless such a substitution should be considered impossible from the standpoint of chemical logic. In connexion with the substitution of phosphorous by other elements (S, Si, C) there arises the question of how do they group with oxygen ions within the crystal and what is the nature of the sulphates, silicates and carbonates which are isomorphous substituents of the phosphate in normal apatite. The substitution of carbon for phosphorous implies the conception of a spatial group CO_4 as a substituent for the group PO_4 in the crystalline lattice. So far as no definite charge is assigned to this group, it is obviously nothing but a symbol of a geometric configuration of the positions certain ions occupy in the lattice, and can in no way be connected with the other components of the crystal. However, with the substitution of the CO_4-group (3,4,5,6) for the PO_4-group in apatite the valency of the central atom is changed and so are naturally the valencies of the rest of the compound, i. e., the CO_4-group doubtlessly acquires the properties of the CO_4^{-4} anion, analogous to the Po_4^{-3} anion.

The CO_4^{-4} anion has never been observed in chemical compounds, and it is therefore easier to the chemist to conceive a carbonate of the apatite type as a double salt $3CaCO_3 \cdot 2Ca(OH,F)_2 = Ca_{10}C_6O_{18}(OH,F)_8 = 2Ca_5C_3O_9(OH,F)_4$, in which the anion $[(CO_3F)_3F]^{-10}$ is contained or, in accordance with the PO_4-group in apatite, the $CO_3(F,OH)$ group in carbonate apatite. If McConnell does not accept the greater «density» of the C^{+4} ions, the compound referred to may be replaced by another—the ternary salt $Ca_3(PO_4)_2 \cdot CaCO_3 \cdot Ca(F,OH)_2 = Ca_5(P_2C)O_{11}(F,OH)_2$.

The chemical formula must present a precise account of the positive and negative charges without which the construction of crystalline lattices of chemical compounds is quite impossible. In some of the recent works, however, the reciprocal compensation of charges between the ions of different valency remained entirely unaccounted. McConnell, for instance, who has shown in one of his papers (4) the substitution of sulphur, silicon, and carbon for phosphorus in apatite, mentions the fact that when a tetravalent element is introduced instead of bivalent calcium, or hexavalent sulphur instead of pentavalent phosphorus, it is necessary to introduce bivalent oxygen instead of monovalent fluorine; he suggests the formula: $Ca_9C(PO_4)_6O_2$ (3), from which it is obvious that an increase of valency by 2 in the (10 Ca)-group involves a similar increase in the (2F)-group, which is replaced by the (2 O)-group. In his recent paper (6) McConnell gives less explicit formulae $(Ca,X)_{10}O_2(PO_4)_6$ and $Ca_{10}O_2(P,X)_6O_{24}$, which fail to consider quantitatively the changes which must take place in the compound when one of its constituents is replaced by another of different valency. They should be represented as follows: $Ca_8(Ca,X)_2(O,Y)_2(PO_4)_6$ and $Ca_{10}(O,X)_2P_4(P,Y)_2O_{24}$, in order to show that the change of valency in one of the constituents quantitatively necessitates a corresponding change of valency in another constituent. It would be still more correct to represent them as two quite definite compounds [$Ca_{10}O_2P_4S_2O_{24}$ and $Ca_{10}(F,OH)_2P_6O_{24}$]. Thus, in spite of his taking account of the change of valencies in the 10Ca, 2F and 6P-groups, McConnell proceeds to a statistical distribution of ions into 42 theoretical positions without any consideration whatever of the substitution of $Ca \rightarrow Na$ and $P \rightarrow C$, and obtains data tabulated below.

In calculating the positive and negative charges, we obtain for dahllite 49.84(+) and 51.34(—), for francolite 49.57(+) and 49.732(—), for ellestadite 49.77(+) and 50.72(—), which is quite unacceptable, since the positive and negative charges should be equal. This inconsistency would not have taken place however, if the results of isomorphic substitutions had been represented as a series of chemical compounds with the same chemical formula of apatite $A_{10}B_6(X)_{26}$, where each change of valency of one of the

	For dahllite	For francolite	For ellestadite
10 Ca=	9.25 Ca+0.24 Na+ +0.06 K+0.45 C	9.810 Ca+0.077 Mg+ +0.113 C	9.92 Ca+0.06 Mg+ +0.02 C
6 P=	5.30 P+0.01 S+0.01 Si +0.08 Al+0.54 C	5.322 P+0.026 V+ +0.632 C	0.44 P+2.62 S+ +2.82 Si+0.12 C
2 F=	0.10 F+0.01 Cl+ +0.55 OH+1.34 O	2.000 F	0.30 F+0.47 Cl+ +0.51 OH+0.72 O
24 O=	24 O	23.732 O+0.100 OH+ +0.168 F	24 O

constituents had involved a corresponding change of valency of some other constituent.

In the analyses I interpreted in this way (7), the rather considerable excess of water and carbonate (not fitting into the formula) obtained in one case (francolite) suggested the possibility of the presence of the CO_2-solution in the pores of francolite crystals; in other cases (ellestadite), where deficiency of water and an insignificant excess of CO_2 have been observed, this could be referred to the summed up (8) error of all the determinations.

I wish to say, moreover, a few words about the accuracy of the chemical analysis in the case of such a complex compound as apatite.

The skill of the analysts carrying out the determinations is to a certain extent a guarantee for the accuracy of the figures obtained. On the other hand, however, pure native material required for the fine measurements of the crystalline lattice is available only in small quantities and this fact accounts for impossibility to bring the analysis to the degree of precision attainable by means of repeated determinations of each constituent; furthermore the methods of determination of all constituents of apatite cannot be regarded as absolutely quantitative. Thus, the problem of SiO_2 determination in the presence of fluorine and phosphoric acid is far from being completely solved, while that of the determination of water in apatite is complicated by the fact that water is removed from the hydroxyl-apatite molecule at higher temperatures (about 1200°). The lead monoxide used for smelting does not help to solve the question, since a lead hydroxyl-apatite (9) is formed which gives off water also with difficulty.

The author trusts that an exchange of opinions between chemists and crystallo-chemists will contribute to a closer collaboration, and this will help to solve a number of problems arising in connexion with the study of the distribution of elements of chemical compounds in the crystalline lattice.

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GENETICS

INHERITANCE OF NICOTINE AND ANABASINE IN INTERSPECIFIC HYBRIDS *NICOTIANA RUSTICA* L. × *N. GLAUCA* GRAH.

By N. I. ŽUKOV

(Communicated by N. I. Vavilov, Member of the Academy, 13. XI. 1938)

Crosses *N. rustica*×*N. glauca* are of great interest in regard to breeding new economically valuable forms owing to the great diversity of characters in these species; the latter is especially true of the alkaloid content in them and of their behaviour in hybrids.

Different forms of *N. rustica* contain different quantities of the alkaloid nicotine, while the other species, *N. glauca*, contains in small quantities another alkaloid, anabasine; nicotine is entirely missing in it ([4,5,6,7]).

Commercial production of anabasine is based on the wild growing half-shrub *Anabasis aphylla*; in the youngest parts of this plant is contained up to 2.53% of anabasine ([1]). The demand for anabasine cannot be wholly satisfied owing to the low proportion of it in *A. aphylla* and to limited production. Breeding a new form rich in abasine is, therefore, not only of theoretical but also of practical interest.

As a material for the investigation were used F_1 hybrids *N. rustica* × ×*N. glauca*, polyploids and later generations of these crosses. Progeny of a back-cross (*N. rustica* var. *texana*×*N. glauca*)×*N. rustica* var. *humilis* was given to me in 1937 by Dr. D. Kostoff for further study.

Analysis of the leaves of the hybrids *N. rustica*×*N. glauca* and of the parental forms gave the following results (Table 1).

Table 1

Forms investigated	Number of plants investigated	Chromosome number 2 *n*	Nicotine content in %		Anabasine content in %	
			pruned plants	unpruned plants	pruned plants	unpruned plants
N. rustica (24 *rr*)	3	48	2.26	7.81	0	0
N. glauca (12 *gg*)	3	24	0	0	0.84	0.69
Amphihaploid (24 *r*+12 *g*) .	3	36	0	0	0.57	—
Sesquidiploid (24 *r*+12 *gg*)	6	48	0	0	0.72	2.03
Do (24 *rr*+12 *g*)	6	60	0	0	1.89	6.61
Amphidiploid (24 *rr*+12 *gg*)	20	72	0	0	1.52	6.06

The data presented in the table corroborate the conclusions reached by us previously (3). Dominance of anabasine over nicotine is observed. In unpruned F_1 amphihaploid hybrids, in polyploids with a single genom of *N. rustica* and in those with two genoms of *N. glauca* the percentage of anabasine does not exceed that in *N. glauca*.

The anabasine content in amphihaploids was lower than in polyploids $24r+12gg$. The pistil parent of these hybrids was the form of makhorka Abissinia «Colubi».

Ternovsky, Khmura and Žukov (3) have suggested that in the presence of the whole genom of individual chromosomes of *N. glauca* containing genes which determine the transformation of nicotine into anabasine, the genes which determine accumulation of nicotine stimulate the formation of corresponding quantities of anabasine. This idea finds its further support in the fact that pruned forms of hybrids and polyploids displayed an increase in anabasine content which rather closely approximated or even was equal to that of the original parental form of *N. rustica*. In *N. glauca* the pruning does not increase the anabasine content, but, on the contrary causes a certain decrease. Anabasine contained in F_1 hybrids and in polyploids behaves after pruning like nicotine, showing a great increase as compared with unpruned plants.

The chemical analysis of 6 polyploids containing two genoms of *N. rustica* and one genom of *N. glauca* has shown insignificant variation of anabasine content in individual plants. The extremes were 1.72 and 2.04% of anabasine. Amphidiploid plants showed variation in anabasine content from 4.19 to 8.04%. The 20 amphidiploid F_3 plants investigated showed the following distribution according to anabasine content: from 4 to 5% — 2 plants, from 5 to 6%—2 plants, from 6 to 7%—6 plants, and from 7 to 8%—6 plants. Amphidiploids showed segregation not only for anabasine content, but also for morphological characters and fertility.

An analysis for anabasine content in stems of plants has shown that sesquidiploids $24\ rr+12\ g$ contain 0.97% of anabasine, while amphidiploids contain 1.04%. As regards nicotine it was totally absent in either case.

The analysis of leaves of the progeny from back-crosses (*N. rustica*×*N. glauca*)×*N. rustica* which was grown in 1937 is presented in Table 2.

Table 2

Total number of plants investigated	Among them		
	Plants containing only anabasine	Plants containing only nicotine	Plants containing both anabasine and nicotine
44	10	4	30
%	22.8	9.1	68.1

Seeds obtained from selfing plants to which Table 2 relates were planted in the spring of 1938.

The progeny of the one of the above-mentioned plants which contained only anabasine (1.66%) was investigated for the behaviour of alkaloids. The analytical data are given in Table 3.

From the data presented in Table 3 it is evident that anabasine-bearing plants obtained in 1937 were segregating into anabasine-bearing, nicotine-bearing and those which contained the two alkaloids together.

Table 3

Total number of plants investigated	Among them		
	Plants containing only anabasine	Plants containing only nicotine	Plants containing both anabasine and nicotine
105	41	40	24
%	39.0	38.1	22.9

The existence of forms which contain both nicotine and anabasine demonstrates the absence in them of the gene (or genes) causing transformation of nicotine into anabasine. This was confirmed by analysis performed by me: a number of families which contained both nicotine and anabasine gave no progenies showing only anabasine. These families segregated into plants which contained nicotine and those possessing both nicotine and anabasine. All the anabasine-bearing plants morphologically belonged to typical makhorka and were self-fertile. The anabasine content varied in these plants from 0.87 to 2.03%. The analysis of leaves was conducted on unpruned plants. By means of pruning and other agrotechnical treatment this percentage may be increased several times. Chromosome counts in the meristem of the root-tips of individual plants revealed 48 chromosomes, i. e. the number of the maternal form of makhorka.

According to data of Dr. D. Kostoff, the reduction division in hybrids *N. rustica*×*N. glauca* follows the «Drosera-scheme» ([2]). The same was confirmed by me on a large material.

Basing upon these data, the formation of anabasine-bearing forms of the makhorka-type may be explained by replacement of the one or several chromosomes of *N. glauca* or by the exchange of certain regions of the chromosomes of makhorka for those of *N. glauca* at the time of conjugation.

The want for anabasine makes it desirable to start the practical breeding work in order to produce varieties of makhorka with high anabasine content; the above data render it possible.

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GENETICS

A TETRAPLOID RUBBER PLANT *TARAXACUM KOK-SAGHYZ* OBTAINED BY COLCHICINE TREATMENT

By DONTCHO KOSTOFF and E. TIBER

(Communicated by N. I. Vavilov, Member of the Academy, 27. XI. 1938)

The plant *Taraxacum Kok-saghyz* is a perennial wild growing dandelion from Tian-Shian, recently introduced in cultivation because of its rubber content. The largest amount of rubber is accumulated in the roots.

The relatively slow growth of this plant and the formation of very thin root are its negative characters. By the end of the first year growing, the weight of the fresh roots of each plant usually is on the average 6—10 g (1). Under more favourable conditions it may be considerably increased. It can be also increased by plant-breeding work.

Analytic (individual selection from populations) and synthetic (selection in populations produced by hybridization) methods to obtain better genotypes are two principal methods for the improvement of this plant newly introduced into cultivation. Alongside of these, chromosome duplication is another method that promises a total increase in the raw material.

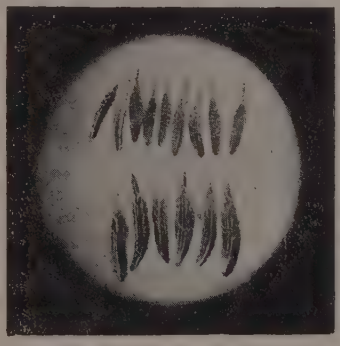
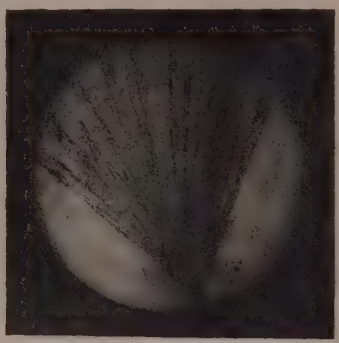


Fig. 1. Seeds from *Taraxacum Kok-saghyz*. Above, the smaller, from a diploid plant; below, the larger, from a tetraploid plant.

We attempted to double the chromosome number by colchicine (2) treatment. Seeds from *T. Kok-saghyz* were soaked for 20 hours in 0.25% colchicine solution and then transplanted into pots. Colchicine treatment suppressed enormously the growth of the treated seedlings during the first forty days. They began to grow normally after about six weeks. In nearly three months they recovered completely and almost reached the control plants. Individual plants, however, from the treated seedlings still formed somewhat abnormal leaves. In studying the morphological appearance and the cytological behaviour of the plants, we found that one plant of the treated series had thicker leaves and larger pollen grains compared to controls. In studying the meiosis in aceto-carmine smear preparations, we found second metaphases with 16 chromosomes. It should be mentioned here that normal plants have $n=8$ and $2n=16$, as shown by Podoubnaya-Arnoldi and Dianova (3). It is a diploid species like *Taraxacum nutans*, *T. vernale*, etc. We would mention

too that tetraploid species, namely, *Taraxacum hibernum* ($2n=32$), have also been found in nature and that triploid (*T. robustum*) and pentaploid (*T. montanum*) do also exist. These data show that polyploidy in *Taraxacum* is a phenomenon of frequent occurrence and that artificial chromosome



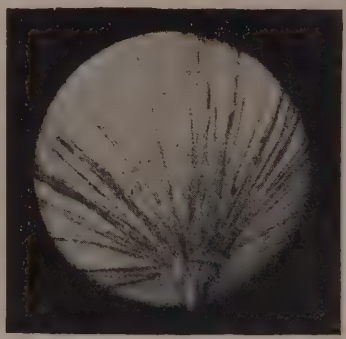


Fig. 2, 3. Trichomes from the upper part of the seeds of diploid (2) and tetraploid (3) plants.

doubling will be no negative element in *Taraxacum Kok-saghyz* from an evolutionary point of view.

Our tetraploid *T. Kok-saghyz* plant flowered and set sexually much larger seeds than the diploid ones. The head, from which we collected the seeds, contained 27 normal well developed seeds and 12 abortive, i. e. a percentage of about 70% of normal seeds. This can be considered as a very high

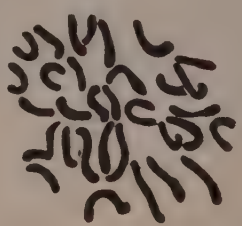


Fig. 4. Somatic plate of a tetraploid (F_2) seedling.

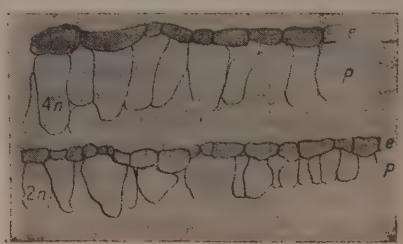


Fig. 5. Cross-section from diploid ($2n$) and tetraploid ($4n$) leaves: *e*, epidermis; *p*, palysad cells.

percentage since autopolyploids usually set a lower percentage of seeds in the first generation, while in the subsequent generations strains can be selected with highly increased fertility. It should be mentioned here that the controls growing under the same conditions set about 25—35 seeds per head.

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GENETICS

NICOTINE AND CITRIC ACID CONTENT IN THE PROGENY OF THE ALLOPOLYPLOID HYBRID *N. RUSTICA* L. × *N. GLAUCA* GRAH.

By DONTCHO KOSTOFF

(Communicated by N. I. Vavilov, Member of the Academy, 13. XI. 1938)

The allopolyploid di-*rustica*-di-*glauca* has originated through chromosome duplication in the first generation of the hybrid *Nicotiana rustica* ($n=24$) × × *N. glauca* ($n=12$) (1). It had 72 somatic chromosomes and was partly fertile and dwarfish, while the F_1 hybrid developed normally and was self-sterile. In studying the meiotic processes in the allopolyploid di-*rustica*-di-*glauca* hybrid, I frequently observed multivalent chromosomes (quadrivalents and trivalents with univalents) during the first meiosis due to auto- and allosyndesis. It is noteworthy that allosyndesis between *N. glauca* and *N. rustica* chromosomes was also observed in the F_1 hybrids which formed a variable number of bivalents (sometimes up to 12), some of them being heteromorphic. The appearance of 24 univalents and rarely of one bivalent in *N. rustica* ($n=24$) haploid (2) indicates that the bivalents in F_1—*rustica* × *glauca*—result from allosyndetic pairing, i. e. from chiasma formation between *N. rustica* (*r*) and *N. glauca* (*g*) chromosomes.

Allo- and autosyndetic chiasmata *(r—r—g—g)* of the multivalents formed among *N. glauca* and *N. rustica* chromosomes in the allopolyploid di-*rustica*-di-*glauca* are responsible for the formation of unequal gametes. The unconstancy, i. e. the segregations in the subsequent generations of this allopolyploid, is consequently due to the exchange of parts between *N. rustica* and *N. glauca* chromosomes in the multivalent groups, as it was clearly shown for the allopolyploid *N. glauca* × *N. Langsdorfii* (3).

The progeny of the dwarf allopolyploid *N. rustica* × *glauca* differed enormously with respect to their morphological, physiological and biochemical characters. In the second, third and fourth allopolyploid generation (A_2, A_3, A_4) there were dwarfs (about 40 cm), giants (about 250 cm), and all transitional forms between these two extremes. Similar amplitudes of variations were observed in respect to sizes and shapes of leaves, sizes and shapes of flowers and the vegetation periods, the latter and the length of the petioles showing even a transgressive segregation in respect to those of the parental forms. There were segregates which developed very rapidly and formed a larger amount of green mass (leaves and stems), than the parental species *N. glauca* and *N. rustica*. A more detailed description of their morphology and cytogenetic behaviour will be given elsewhere. Here I wish to point to the alkaloid and citric acid contents of some plants of the fourth generation (A_4) of the allopolyploid di-*rustica*-di-*glauca*, grown in 1937. Determinations of citric acid and alkaloid contents were carried out in the Biochemical Laboratory of the Institute of Genetics under the direction of Prof. A. A. Shmuck to whom thanks are due.

The data given in Table 1 show that the original species *N. rustica* contains alkaloid nicotine, while the other parental species *N. glauca* and all allopolyploids contain alkaloid anabasine with a single exception, namely plant No 75006-108, which contains both alkaloids—nicotine and anabasine. The studies by the collaborators of the Tobacco Institute ([4]) showed that in species crosses, when one of them has nicotine, and the other anabasine, F_1 hybrids contain, as a rule, anabasine. The behaviour of the progeny of our allopolyploid confirms this rule. In crossing F_1 *N. rustica* × *N. glauca* back to *N. rustica* and selfing the backcrosses I obtained abundant material which was given to N. I. Žukov for further study. I grew in 1937 a few families of it, and the results of the chemical analysis of some plants are given in Table 2. The data show that they contain both alkaloids, nicotine and anabasine. Large number of analyses carried out by Žukov (in press and unpublished) upon the same material during two generations showed that plants having anabasine segregate into: 1) plants with anabasine and 2) plants with both anabasine and nicotine, while plants having both anabasine and nicotine never give rise to plants only with anabasine. Such a behaviour of the alkaloids suggests that the allopolyploid No 75006-108 is a segregate, resulting from crossing-over between *glauca* and *rustica* chromosomes carrying the gene or genes that are involved into the formation of the alkaloids.

Three different segregates from the allopolyploid di-*rustica*-di-*glauca*.

In studying the citric acid content (the plants contain it in form of salts) in the allopolyploid segregates (Table 1), it was found that they have very different contents of these substances although they grew under equal environmental conditions together with the parental species. Segregate No 75006A had, for example, 1.319% of citric acid, segregate No 75006-101 had 4.967% of this substance, while the parental forms had: *N. rustica*—5.595% and *N. glauca*—3.036%.

Allopolyploid *N. rustica—glauca* is a plant interesting from agricultural point of view, because it segregates forms with larger amount of anabasine (1.986, 1.449, 1.395%, etc.) than the parental species *N. glauca* which, when grown under the same environmental conditions, contained 0.837%. At the same time the offsprings contain a relatively large amount of citric acid. Further generations of some of the offsprings should give the possibility to select forms with larger content of anabasine and citric acid. The populations produced from the backcrosses can be used for the same purpose. It should also be mentioned here that anabasine content can be increased about three times after decapitation, as the analysis by Žukov showed.

Alkaloid anabasine is one of the most important insecticide substances. It is produced until now from the wild growing bush *Anabasis aphylla*. This plant contains about 1.3—2.0% of anabasine. Young parts of the plant contain up to 2.53% of anabasine, but the production of anabasine from

Table 1

Alkaloid and Citric Acid Content in the Amphidiploid *Nicotiana rustica* × *N. glauca* and in the Original Species

№	Plants	% of alkaloid content			% of citric acid content
		nicotine %	anabasine %	total alkaloid content %	
1	*Nicotiana rustica*	2.059	0	2.059	5.596
2	*Nicotiana glauca*	0	0.837	0.837	3.036
	Allopolyploid *N. rustica* × *N. glauca*:				
3	75006-1	0	1.423	1.423	2.428
4	75006-100	0	1.232	1.232	—
5	75006-101	—	—	—	4.967
6	75006-102	—	—	—	3.025
7	75006-103	0	0.971	0.971	4.679
8	75006-104	0	1.449	1.449	3.263
9	75006-105	0	1.182	1.182	4.397
10	75006-106	0	1.088	1.088	3.572
11	75006-107	0	1.395	1.395	4.447
12	75006-108	0.093	0.509	0.602	2.937
13	75006-109	0	0.753	0.753	3.431
14	75006-111	0	1.204	1.204	3.529
15	75006-A	0	1.386	1.386	1.319
16	75006-B	0	1.986	1.986	1.675
17	75006-E	—	—	—	2.081

Table 2

Citric Acid and Alkaloid Content in Some Plants of the $F_{3/4}$ Generation from the Backcross (*N. rustica* × *N. glauca*) × *N. rustica*

№	$F_{3/4}$ of the backcross (*N. rustica* × × *glauca*) × *N. rustica*	Nicotine %	Anabasine %	Total alkaloid content %	Citric acid %
1	75115-1	0.927	0.403	1.330	—
2	75133 *c*-2	—	—	—	2.554
3	75133 *c*-3	0.654	0.648	1.302	4.856
4	75133 *c*-5	1.140	0.502	1.642	5.118
5	75133 *c*-6	0.645	0.718	1.363	—
6	75134 *b*-1	—	—	—	3.964
7	*Nicotiana glauca*	0	0.837	0.837	3.036
8	*Nicotiana rustica*	2.059	0	2.059	5.595

A. aphylla is far from covering the needs of this chemical. Some of the allopolyploid segregates, on the other hand, grow very rapidly and give a very large amount of green mass, provided suitable environmental conditions are secured for their growth.

Considering all these facts, I think that our allopolyploid *N. rustica*—*N. glauca*, as well as the backcrosses and other hybrids between *N. rustica* and *N. glauca* that are studied now at the All-Union Tobacco Institute by N. I. Žukov, may answer the demands of the industry, if breeding work with these plants be done on a somewhat larger scale.

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GENETICS

CYTO-GENETIC EXPERIMENTS WITH *NICOTIANA TRIGONOPHYLLA* DUN.

By S. A. EGHIS and F. A. FATALIZADE

(Communicated by N. I. Vavilov, Member of the Academy, 3. XI. 1938)

Of the small group of nine species of *Nicotiana*, endemic to the western part of North America, at least four were being used for smoking by the various local Indian tribes. These tribes, which knew neither *N. tabacum* nor *N. rustica*, sought out narcotic plants precisely from among the species of *Nicotiana* in the local flora. All four species—*N. quadrivalvis* Pursh., *N. multivalvis* Gray, *N. attenuata* Torr. and *N. trigonophylla* Dun.—are considerably inferior, as regards the size of the plants and leaves, to the widely cultivated (thanks to the Europeans) forms of tobacco (*N. tabacum* and *N. rustica*), and their low productivity was possibly one of the reasons why these species were neglected by Europeans. The Laboratory of Tobacco and Tea of the Institute of Plant Industry, which is engaged in the study of the whole of the genus *Nicotiana*, included these species as well, with the aim of testing the possibility of their practical utilization.

Nicotiana trigonophylla Dun. is one of the most interesting species of North America. Its haploid chromosome number is 12; it has the largest area of distribution (Mexico, Texas, Arizona, Utah and California), comprises several varieties, and is comparatively easily cultivated, the plants being strong and healthy. But this is the smallest of all the above-mentioned species and it has very small flowers. According to East, *N. trigonophylla* is, as a rule, difficult to cross with other species. Goodspeed states that this species has the smallest chromosomes of all tobacco species, but he supplies data from hybridization experiments with this species, showing its chromosomes to conjugate rather completely with the chromosomes of *N. nudicaulis* Watson ($n=24$), *N. tomentosa* R. a. P. ($n=12$), and *N. tomentosiformis* Goodspeed ($n=12$).

Origin of the Autotetraploid *N. trigonophylla*. Our attemps to cross *N. trigonophylla* with *N. paniculata* L., *N. glauca* Grah., *N. Bigelovii* Wats., *N. silvestris* Speg. a. Comes, and *N. tabacum* L. by simple pollination proved a failure. In order to avoid the dropping off of the many-seeded ovaries of *Nicotiana*, which is likely to occur if but a few ovules are fertilized, we adopted the method of mixed pollination, placing on the stigmas of *N. trigonophylla* at first a small quantity of its own pollen and then a large quantity of pollen from another species. In such an experiment (Eghis), in which the pollen of *N. quadrivalvis* was used, a small number of seeds were obtained, from which five plants were grown. Among them there was one plant differing from the others, and this proved to be no hybrid but an autotetraploid (Fig. 1). It had somewhat larger and broader leaves and flowers than the diploid, and its fertility was but slightly reduced.

Crossability of the Tetraploid. Besides morphological differences, the tetraploid differed very much from the diploid in its crossability with other species. This was especially marked in crosses with

N. tabacum ($n=24$) and *N. quadrivalvis* ($n=24$), several hybrids being obtained from simple pollination, and even more marked in crosses with *N. silvestris* ($n=12$), in which case many hybrid plants were obtained. On the other hand, when the tetraploid was pollinated with pollen from diploid *N. trigonophylla* [or from *N. paniculata* ($n=12$)], although a considerable number of seeds were obtained, they failed to germinate. From reciprocal cross no seeds at all were obtained. The autotetraploid *N. trigonophylla* is thus distinct from the diploid form. By means of pollination of this tetraploid with pollen from *N. glauca* ($n=12$) a considerable number of seeds and several seedlings was also obtained, but the latter proved not viable, thus showing the physiological incompatibility of these species.

Fig. 1. Leaves, flowers and capsules of *N. trigonophylla*; of the autotetraploid (larger) and of the diploid (smaller).

Fig. 2. Somatic plate (metaphase) from the root-tip of the autotetraploid (48 chromosomes).

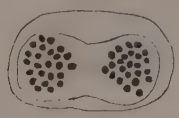

Fig. 3. Second metaphase of a pollen mother-cell of an autotetraploid.

Cytological Investigation of the Autotetraploid. Root-tips and anthers were fixed with Navashin's 10 : 4 : 1 solution. Sections of root-tips were stained with iron-haematoxylin; those of anthers, with gentian-violet. Both permanent and aceto-carmine preparations were used for the study of meiosis. The annexed figures were taken with the aid of an Abbé camera lucida, all drawings of pollen mother-cells being given with the same magnification.

The five autotetraploid plants investigated, obtained in the direct progeny of the original autotetraploid, had 48 as their somatic chromosome number (Fig. 2). In their root-tips there were found no diploid sectors or even single diploid cells. Meiosis in these plants was slightly irregular, due to the formation of trivalents and quadrivalents. In most cells at the first metaphase there were 24 chromosome bodies; but rarely some other number was found. At the first anaphase lagging of chromosomes was rarely observed, and at the second anaphase very rarely. At the second metaphase there were, as a rule, 24 plus 24 chromosomes (Fig. 3). The pollen was normal in appearance; 98—99% of it stained with carmine.

Cytological Investigation of the Hybrid between Tetraploid *N. trigonophylla* and Diploid *N. silvestris*. The hybrid plants (Fig. 4) are intermediate in size and shape; the flowers approach in size and shape to *N. trigonophylla*. Their somatic chromosome

number is 36. Meiosis is very irregular at all phases. At the first metaphase 12 chromosome bodies are concentrated in the center of the plate in one plane, the rest (usually 12) are scattered in different planes along the periphery of the cell. Most frequently there are found 24 bodies, but the number varies from 21 to 26. At the first anaphase there are many lagging chromosomes. At the second metaphase in one nucleus there are from 12 to 18 bodies and in the other, respectively, from 24 to 18, the total being 36, except in two cases, when it was 37 (being, probably, due to the splitting of a univalent). The second anaphases are irregular. The sporads formed range between monads and hexads. The pollen grains vary in size, 59 to 62% of them stain, but the hybrids are absolutely sterile. At the second metaphase (Fig. 5) there are seen 12 small chromosomes and a certain number of larger chromosomes, corresponding, respectively, to the small univalent chromosomes of *N. trigonophylla* and the larger chromosomes of *N. silvestris* (Fig. 6).

Fig. 4. Left, tetraploid *N. trigonophylla*; right, diploid *N. silvestris*; center, hybrid between them.

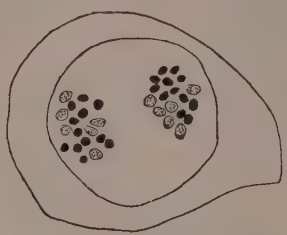

Fig. 5. Second metaphase of a pollen mother-cell of the hybrid *N. trigonophylla* (tetraploid)×*N. silvestris*. The larger stippled chromosomes are those presumably derived from *N. silvestris*.

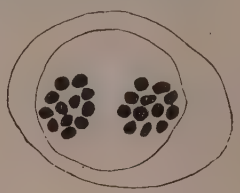

Fig. 6. Second metaphase of a pollen mother-cell of *N. silvestris*.

If it is true that within the limits of the genoms of each of the components of the hybrid there are chromosomes differing in size, nevertheless the considerable difference in the size of the chromosomes of these two species gives grounds for assuming that the small chromosomes at the second metaphase probably belong to *N. trigonophylla* and the large ones to *N. silvestris*.

Conclusions. In order to introduce a wild species into cultivation, it is most natural to adopt the method of interspecific hybridization. However, in adopting this course one may at once encounter a serious obstacle, viz., the non-crossability of species in their diploid form. To overcome such non-crossability one may take advantage of the tendency of many flowering plants to give rise, under various conditions, to polyploid forms which, while differing comparatively little from diploid forms in morphological characters, show marked differences from other species as regards crossability. The crossability of the autotetraploid *N. trigonophylla* depends neither on phylogenetic affinity (it does not cross with its diploid form), nor on similarity or dissimilarity in number, homology, or size of chromosomes (it crosses with *N. silvestris*, *N. tabacum*, *N. quadrivalvis*). For lack of more definite data, crossability can be detected only empirically.

The hybrids obtained from crosses between the autotetraploid *N. trigonophylla* and other species of *Nicotiana* proved sterile. Since, however, the cause of this sterility is a cytological one, we know how to overcome it.

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PLANT PHYSIOLOGY

PLANT'S UPTAKE OF POTASSIUM AND YIELD AS INDUCED BY SODIUM CHLORIDE

By W. S. BUTKEVICH, Corresponding Member of the Academy, and L. V. MARUASHVILI

The influence of sodium salts upon the uptake of the potassium by the plant has already been discussed in literature ([1–4]), yet the data available are conflicting: in some cases a stimulating, in others an inhibiting influence has been reported. The cause of the disagreement being insufficiently clear, one could suppose it in the predominance of some or other ion of the sodium salt according to the concentration of the latter. Stimulating influence of the anions on the diffusion of the cations is a physico-chemical phenomenon well established by our experiments on diffusion of salts through dead films ([5]). Antagonistic interrelations between the cations observed on their entering the living cells may possibly be brought in connexion with the specific structure of the plasmatic films, which imparts them the power to adsorb cations. It would seem probable that, as the concentration of the sodium salt grows, the depressive action of its cation on the potassium uptake in the cell becomes more and more predominant over the stimulating influence of the anion and finishes with creating its total effect in the form of an antagonistic depression.

To throw more light on these interrelations we set up a number of experiments concerned with the influence of sodium chloride upon plant's uptake of the potassium from its salt solutions.

For the experiment we took young plants of wheat and maize grown in water culture and given normal Hellriegel's medium with the addition of microelements according to Schropp and Scharrer ([6]).

In testing the influence of NaCl upon the absorption of the potassium by the root system we put the plants in potassium salt solutions of equal concentration (millimolar, 75 mg of KCl per 1 l) with and without addition of different amounts of NaCl (from 1 to 9 millimoles, i. e. from 60 to 540 mg per 1 l). Each of the vessels used for that purpose contained 500 cm^3 of the solution under test and there was room for seven wheat or two maize plants to grow in it. Potassium content in the solution was estimated after 4, 6 and 8 hours, and the course of its absorption by the plant in terms of the concentration of its attendant sodium salt was there established. In all of the experiments, both with wheat and maize, this dependence proved to bear the same character whatever the potassium salt taken. The uptake of potassium by the plants increased with the concentration of NaCl until the latter attained a certain limit whereupon it began decreasing. The results obtained with the solutions, in which KCl was attended by NaCl, are represented in Fig. 1 and 2. Similar curves were obtained with other salts of potassium

except for their bending points being somewhat shifted towards the left or right side.

Thus, with moderate concentrations of sodium chloride we see the latter to accelerate the uptake of potassium, and this indeed had we to expect both from theoretical considerations regarding the interaction of ions in a solution and on ground of the experiments with dead films. This effect is connected with the increase in the concentration of the anions in the solution. When raising the concentration of NaCl beyond a certain limit, we reach however a turning point which is a manifestation of antagonistic relations between ions of K and Na. To some extent these relations manifest themselves with lower concentrations too, but they are masked by an opposite influence of the sodium salt anion. Sodium, with the increase of its

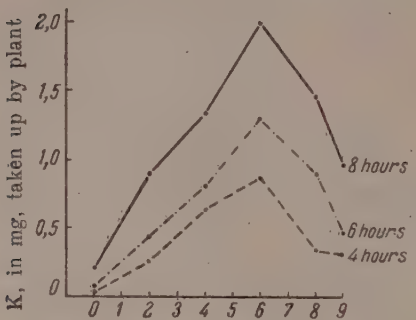

Fig. 1. Experiments on wheat plants. Uptake of potassium from KCl solutions (75 mg per 1 l) as dependent on the amount of its attendant NaCl.

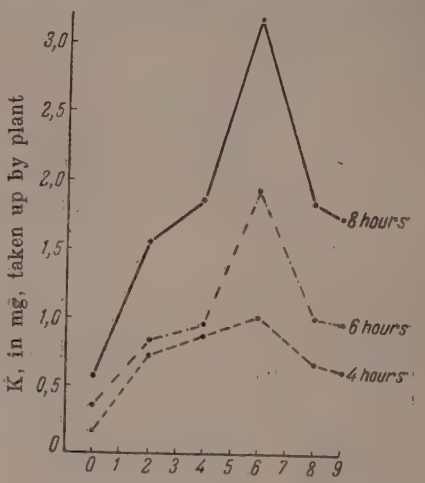

Fig. 2. Experiment on maize plants. Uptake of potassium from KCl solutions (75 mg per 1 l) as dependent on the amount of its attendant NaCl.

salt concentration, is adsorbed by the plasmatic film which it saturates, thus obstructing the way for potassium.

Alongside of the short experiments described above, we have been carrying on long ones with wheat in sand culture and with maize in water culture. In those experiments we traced the influence of additional amounts of NaCl introduced into the nutritive medium on the total yield and the uptake of potassium. There too we observed a stimulation of potassium uptake within certain range of NaCl concentration, followed moreover by considerable increase of yield. The latter fact seemed to be connected not only with the enhanced uptake of potassium, but also with other sides of the action of Na salt. As one of the manifestations of this action, we noted a markedly stronger development of the root system in maize.

With 3—4 NaCl per 1 K the total content of potassium in the yield of wheat was more than twice that of the control (deprived of NaCl). It went down, however, with further adding of NaCl to the culture solution, still remaining higher than in the control even with 8 NaCl.

With the addition of 4—5 NaCl the maximum increase of the total yield was 25% in the case of wheat and 60% in the case of maize, as compared to control, which lacked NaCl. Fig. 3 is a graphical representation of these experimental results.

Further on we carried out experiments with peas and oats in sand culture (Prianishnikov's medium) where potassium was partly replaced by sodium, and with wheat in water culture (Hellriegel's medium) from which at certain periods of plant's development potassium was entirely eliminated and replaced by equivalent amount of sodium.

The experiments with partial substitution of sodium for potassium showed that the decrease of the yield due to the partial elimination of potassium from the culture solution is to some extent or even completely compensated when this substitution is ranging within 25—75%. Thus was established the possibility partly to substitute sodium for potassium in the supply of the plants without detriment to their development (7).

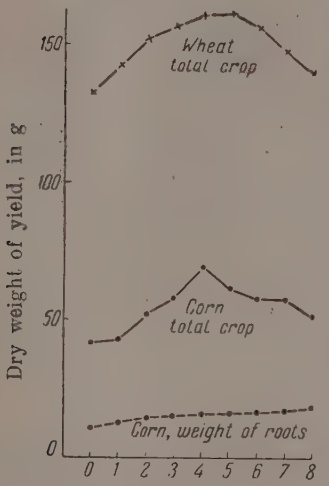

Fig. 3. Experiments on wheat in sand culture and maize in water culture. Plant's development as determined by different amounts of NaCl in the nutrient medium.

Some peculiar alterations were noticed in the structure of the plants, resulting from partial substitution of sodium for potassium: the leaves grew more broad, fleshy and dark, had a higher content of water and were grouped more closely together owing to weaker develop-

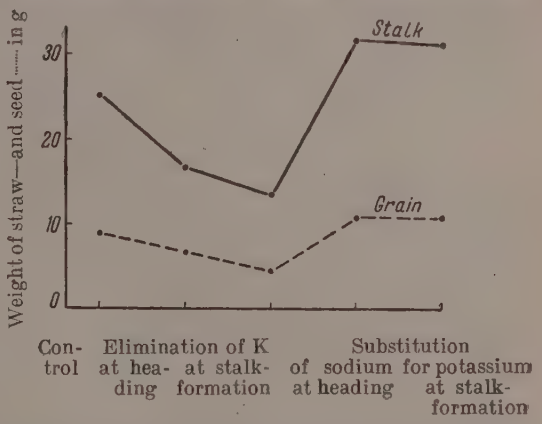

Fig. 4. Experiment with wheat in water culture. Elimination of potassium and its replacement with sodium at the stages of heading and stalk-formation.

ment of the stems. Furthermore, the analysis revealed an intensified transfer of the potassium as well as nitrogen and phosphorus to the young leaves of the plants grown with more sodium in the culture solution (8).

In the experiments on complete elimination of potassium from the culture solution and its replacement with sodium at certain stages of plant's development (at the periods of heading and stalk-formation in the case of wheat), we found such a substitution not only to repair the loss which would have been caused in the yield by the elimination of potassium, but even to increase the yield markedly, compared to the control which was supplied with potassium throughout the vegetation period. Hence, the elimination of potassium from the nutrient medium and its replacement by sodium at definite stages of the vegetation period proved to be favourable for the development of plants. The results of this set of experiments are represented graphically in Fig. 4.

Before we finish we wish to point out the results obtained in supplying the plants with potassium and sodium salts separately. With such a supply we failed to produce the effect observed when both salts were present in the

solution. This points to the effect of the sodium salts on potassium supply being to some extent if not entirely determined by the interaction of the salts in the solution, from which they are taken up by the plant. A new evidence has thus been obtained in support of the considerations one of us has emitted in his previous works concerning this kind of interactions ([5],[9],[10]).

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AGROPHYSIOLOGY

DYNAMICS OF VEGETABLE CELL DECAY DUE TO LOW TEMPERATURE

By M. F. BUGAEVSKY

(Communicated by N. I. Vavilov, Member of the Academy, 11. XI. 1938)

In spite of close attention being paid to the study of causes responsible for the freezing away of winter cereals, we cannot yet state the precise nature of processes involved in the deterioration of plants by low temperatures. This lack of knowledge hinders the development of adequate methods to control the freezing of our winter crops, as well as other agricultural plants.

There are many theories concerning the subject, yet none of them is convincing, since they all appear essentially to contradict one another. It is the theory advanced by Müller-Turgau which now predominates, and it has so deeply rooted that we find it alone referred to in the textbooks for agricultural colleges. According to this theory, the cells die at low temperatures because large amounts of water are withdrawn from the protoplasm of the cell by ice crystals growing in the intercellular spaces.

This explanation seems to us insufficient, since it fails to embrace all sides of the phenomenon.

It is true that the plants attacked by frost die owing to dehydration of their protoplasm; nevertheless this rule fails to manifest itself in all cases and fails to be valid for all vegetables.

The question being of great importance for practical farming, we set before us the task, making good use of the literary data available, to trace the dynamics of the changes occurring in the cells of the plants affected by low temperatures.

Tillered winter wheat sown in fall was chosen as the object of our study. For freezing we made use of a refrigerator and a refrigerating microchamber attached to the microscope, where the object under investigation could be observed both at stable and varying temperatures. The air in the refrigerator was cooled down to —20°C, while the temperature of the microchamber could be brought to —18°C.

It was chiefly the underground part of the winter wheat which was studied under the microscope, since its tissue being devoid of chlorophyll is visible to a greater depth than it is the case with the aboveground parts which are obscured by chlorophyll.

The freezing of the tissue was effected by bringing the temperature slowly up and down. The cuts of the tissue were first to be frozen, then followed separate portions, uncut by the razor, and at last, the whole plants, made beforehand suitable to microscopic investigation upon freezing, which was no matter of considerable difficulty with young plants under our experi-

ment. After being frozen under the microscope, the plants were planted for the estimation of their viability.

The cell looked usually smooth in the field of vision. Gradually reducing the temperature from above zero, we observed, within the range of —3, —7°C, hoarfrost to appear on the surface of the cells and to grow with further increase of temperature both in an air medium and in liquid paraffin oil.

The contents both of the epidermic cells and of those underlying the epidermis presented a smooth surface when viewed through the microscope. Yet, they were liable to sudden changes within nearly —15°, —18°C. The range of temperature, at which the contents of the cells were changing their aspect, varied however, according to the hardiness of the plant.

All over the field of vision we saw distinct crystals of ice to appear at once among cell's contents, and their size was small compared to the field of the cell. The whole field seemed to be studded with minute crystals. This was the first stage of the formation of ice (Fig. 1).

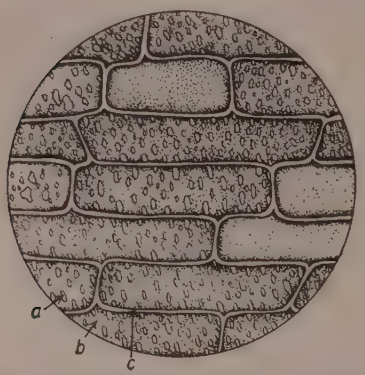

Fig. 1. First stage of ice formation: *a*, ice crystals; *b*, protoplasm; *c*, cell-wall.

The crystals of ice did not form at once in all cells; the latter fell under the action of frost in succession, now by groups, now separately in different places, until all the cells in the field of vision of the microscope contained small ice crystals. Sometimes there occurred such groups of cells as would not freeze for a long time, while ice had already formed in the surrounding cells.

The cell contents were fairly visible as interlayers of various shape and thickness between ice crystals. The latter in growing did not only deform the tender protoplasm, compressing it and taking up water from it, but they also c u t it in different directions, while the interlayers of protoplasm grew more and more thin. The growing of ice went on this way until the whole cell became filled with crystals, and the thin interlayers of protoplasm seem to be squeezed between them. Such cells look opaque because of media of different refringency that are scattered all over it. We thus see that water for the crystals to grow is supplied by the protoplasm. This is the third stage of ice formation * (Fig. 2).

When such cells filled with ice are subjected to gradual thawing, the visibility in the cavity of the cell grew as ice melted away. With the last crystals which we distinctly saw to melt out, the contents of the cell presented a curious picture: the protoplasm was seen in the shape of an irregular net throughout the cavity of the cell. This net owed its formation to the action of ice which had cut the protoplasm in various directions. Ice having melted, the protoplasm fell to the lower wall of the cell (with reference to the position of the preparation under the microscope). Such a torn and cut protoplasm was seen as separate or grouped clots scattered over the base of the cell (respective to the above position). When the plants which had suffered the third stage of ice formation were set in soil, the portions of their tissue affected by frost always died away.

* We may discern three stages in the process of cell freezing beginning with ice formation: first stage—formation of crystals; second stage—half of the cell is filled with ice; third stage—ice crystals have grown as wide as to fill up the whole cavity of the cell, and have ceased further growing.

Consequently, the protoplasm is pervaded by growing ice crystals and torn by them into pieces of different size and shape. The ice being melted, these parts fall to the bottom in the form of a net, to form clots which are distinctly seen under the microscope (Fig. 3).

We therefore refute the opinion advanced by Ilyin, who believes the protoplasm to decay only on thawing.

If the growing of ice be checked before the crystals have filled the cell (at the second stage), the protoplasm will not be so damaged, and some portions of it will be less cut by ice. If again the cell be thawn immediately after ice has appeared (first stage), the protoplasm, though not deeply cut, will none the less lose the aspect it had before freezing: there will be observed a honeycomb structure expressed to different yet everywhere feeble extent, while separate cells will show a kind of abnormal plasmolysis. In some cells a small portion of protoplasm will break off into regular globules of different size.

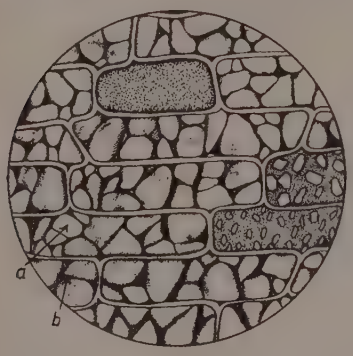

Fig. 2. Third stage of ice formation: *a*, ice crystals; *b*, protoplasm.

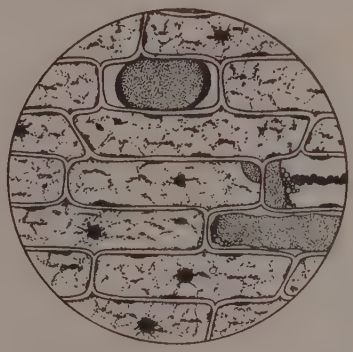

Fig. 3. Protoplasm torn in all the cells (dark clumps) except two cells, where the process of freezing is retarded.

When vegetable tissue is cooled down to the limit of ice formation (without allowing ice crystals to form within the cell), no signs of alterations could be noticed in the protoplasm. The latter, after the tissue was thawn out, had its normal aspect, and few were the cells in which a portion of protoplasm had fallen to pellets of various size. The fact that such cells occurred is, however, evidence of some changes taking place in that case too, but these changes turn out to be so immaterial, as not to affect the viability of the plants which, as we have become convinced later, vegetate at one when set in soil and no dead tissue is observed in them.

Remarkable is that close before the formation of ice the protoplasm is changing its properties especially by increasing its permeability. When freezing plasmolized (in potassium nitrate neutralized with $CaCl_2$) tissue, we sometimes observed the following phenomenon: with the temperature going down the plasmolysis of the protoplasm was retained until it began to vanish rapidly close before the formation of ice, and the protoplasm seemed to straighten itself, whereupon ice formation set in.

As stated by the works of different authors, the cell is supercooled before it begins freezing. It is known that the minimum volume of water corresponds to $+4°C$, to expand further on and assume its maximum volume at the transition to ice, when the volume of water is increased nearly by 10%, owing to which a strong pressure is created.

On the other hand, the wall of the cell, though elastic, shrinks under the action of low temperature. Hence two opposite pressures are created: the compression of cell's contents by its wall and the expansion of water which starts when the temperature drops below +4°C, and attains its maximum on freezing. This results in water breaking out of the cell before the latter is frozen, and turning into irregular layers of hoarfrost outside the cell. With further decrease of temperature the cell contents become supercooled, and after a certain limit is reached ice begins forming in the cell instantaneously.

In the course of ice formation a noticeable pressure is created in the cell, and we observed the wall of the cell to grow frilled with transverse creases which smoothed out upon thawing.

From our numerous experiments we became convinced that, certain conditions being available, ice grows in the cells and tears the protoplasm. Further study has to clear up the process of cell's deterioration by low temperatures under different conditions and for other objects.

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AGROPHYSIOLOGY

FERTILIZERS AS PROMOTERS OF YIELD IN CINCHONA

By G. V. OZEROV

(Communicated by N. I. Vavilov, Member of the Academy, 22. XI. 1938)

Cinchona is cultivated on account of its alkaloids, which are a specific remedy against malaria. The alkaloids are spread in all organs of the plant, yet their amount is greater in the root than in the stem and leaves. The ratio of alkaloids varies according to the species and age of the plant, soil conditions, intensity of illumination and nature of light, temperature and humidity of air. Best soils are considered those which, without retaining excessive humidity, possess high ratios of nitrogen, humus and phosphoric acid. Organic fertilizers are known to stimulate growth and to promote the store of alkaloids in the plant, while the rôle of mineral fertilizers is as yet scarcely studied. Experiments carried out by Lambert and Yersin([1]) at the station of Dran in Indo-China within 1924—1926 have shown the cyanamid, calcium phosphate and potassium chloride to reduce the ratio of quinine and its sulphate. The experiments of 1936—1937 made by Ozerov ([2]) in plot 1 of Sukhumi Introduction Nursery have brought into evidence that growth of cinchona is affected negatively by sulphate and nitrate of ammonium, and positively by nitrate and phosphate of potassium, when the latter are applied to slightly acid argillaceous soil of river alluvium. Further experiments by Ozerov ([3]) have established that cinchona requires a soil of weak alkaline, almost neutral reaction. The acidity of soil being reduced to 7.6 pH, the yield increased by 59 and 50% with reference to vegetative mass and alkaloids respectively. From the experiments of Waksman ([4]), Kappen ([5]) and other investigators we know that an increase of soil salinity favours the development of fungi and hinders that of bacteria, accelerates the absorption of cations by the plant and slows down its absorption of anions, slackens the pace of nitrification processes, while those of denitrification become more rapid. In connexion with those peculiarities of plant and soil stand the negative action of physiologically acid salts and the positive action of physiologically alkaline ones. To clear up the true cause of the same fertilizers playing a different rôle, we set up our experiments in flower pots filled with similar soil, with *C. succirubra* multiplied vegetatively. Ammonium nitrate was introduced against the background of limed soil according to the following scheme: 1) 0.9 g of nitrogen+4.5 g of lime (air slaked) and 2) 1.8 g of nitrogen+9.0 g of lime per 2 kg soil. Potassium nitrate served as control and was introduced in the same ratio as nitrogen, i. e. 0.9 and 1.8 g per 2 kg soil.

Experiment showed the ammonium nitrogen to be no worse stimulator of cinchona growth in limed soil than potassium nitrate is, which proved its favourable influence in the three preceding experiments. Taking into

account the results of previous experiments, we set up a new one on May 15 1937 on plot 1 of Sukhumi Introduction Nursery in earthen pots, with nine test sets and three kinds of soil. Vegetatively multiplied plants of *C. succirubra* were subjected to test. The object of the experiment was to ascertain the rôle of different fertilizers with reference to the reaction of soil and its content of nitrogen, humus and phosphoric acid. The varieties of soil tested were as follows: 1) argillaceous red soil, poorly provided with the various nutritive substances; 2) sandy clayey sea alluvium with high ratio of nitrate nitrogen and humus and comparatively low content of phosphoric acid and ammonium nitrogen; 3) light argillaceous sand of river alluvium, manured with horse dung at the ratio of 30 tons per ha and containing very large proportions of phosphoric acid alongside of a comparatively low percentage of nitrogen and humus. The same soil but without manure was used as control in this latter case.

The first kind of soil had an acid reaction, the two others a weak acid one, approaching to neutral reaction. As fertilizers, we used poudrette, which is a full organic fertilizer, nitrogen, and two forms of phosphoric acid. The following Table 1 is the scheme of the experiment.

Table 1

Variants		Control	NH_4NO_3	KNO_3	KH_2PO_4	$Ca_3(PO_4)_2$	$KNO_3+KH_2PO_4$	$KNO_3+Ca_3(PO_4)_2$	Poudrette
Doze of nutriment per 2 kg soil	N	—	1.8	0.9	—	—	0.9	0.9	50 g
	P_2O_5	—	—	—	1.8	0.9	0.9	0.9	

The fertilizers were introduced in solution at three different times: June 1, July 1, August 1. Watering was performed by sprinkling the plants from above with equal amounts of water per pot. From nine plants tested, six average were taken into account. Analytical estimation of alkaloids after the micromethod was done in the Biochemical Laboratory of the All-Union Institute of Plant Industry. Average indices of alkaloid store are presented in Table 2.

Table 2

Soil / Variants	Red soil				Sea alluvium				River alluvium			
	Weight of plants in g	Ratio of alkaloids in %			Weight of plants in g	Ratio of alkaloids in %			Weight of plants in g	Ratio of alkaloids in %		
		Root	Stem	Leaf		Root	Stem	Leaf		Root	Stem	Leaf
Control . .	20.7	1.04	1.44	1.00	17.6	1.26	1.55	1.11	35.5	1.32	1.34	0.78
NH_4NO_3 . .	37.1	1.28	1.65	1.54	36.9	1.20	1.62	1.29	30.6	1.29	1.44	1.25
KNO_3 . . .	31.3	1.90	2.06	1.27	17.0	1.24	1.24	1.18	52.8	1.83	1.84	1.09
KH_2PO_4 . .	39.5	1.73	1.18	1.01	29.2	1.76	1.33	0.95	54.0	1.78	1.22	1.08
$Ca_3(PO_4)_2$.	25.5	1.10	1.12	1.02	22.0	0.98	1.37	0.99	38.6	1.08	1.18	0.96
$KNO_3+KH_2PO_4$ . . .	57.6	1.75	1.78	1.12	46.1	2.09	2.11	1.17	50.3	1.92	1.89	1.13
Poudrette .	37.1	2.19	2.00	1.16	37.2	1.78	1.70	1.08	65.1	1.66	1.46	1.06

A plant grown in unfertilized river alluvium weighed 24.1 g and contained 1.66, 1.09 and 0.78% of alkaloids.

Thus, out of the three unfertilized soils tested, the light argillaceous river alluvium, with high ratio of phosphoric acid, was found to be most suitable for the growth of cinchona. There the yield of vegetative mass had increased by 16% compared to red soil and by 32% as against sea alluvium. Argillaceous red soil, in which nearly all nutritive substances were in deficiency, proved to be less favourable for the growth of plants than the first kind of soil, being however superior to sea alluvium. The latter, despite its exceedingly high content of nitrate nitrogen, which is unfortunately attended by a rather low ratio of ammonium nitrogen and, especially, phosphoric acid, affected the growth of plants unfavourably, even if compared to red soil. But though the plants grown in this soil gave a lower yield of vegetative mass, yet their content of alkaloids proved to be higher than in red soil and the more so, compared to river alluvium.

The weak growth of plants in sea alluvium is accounted for by this soil having been taken near a sloping coast and therefore containing high ratios of potassium, magnesium and sodium salts in the form of sulphates and chlorites, which, according to Main's data ([6]), are endowed with unfavourable action on growth and development of plants. The quantity of ammonia nitrogen in this soil was moreover 19 times below that of nitrate nitrogen, which circumstance could by no means favour the growth of plants, so much the more in the presence of very low percentage of phosphoric acid. The above said is fairly exemplified by potassium nitrate which (being introduced into the soil in two times lesser amount than ammonium nitrate, if calculated to nitrogen) has abated the yield of vegetative mass by 4% and that of alkaloids by 17%, as compared to control. The positive effect of sandy clayey alluvium on alkaloids' store in cinchona seems to be due to the high content of nitrogen, which in the majority of our experiments appeared as a stimulator of alkaloid storing.

No doubt, the efficiency of fertilizers for annual cinchona culture is in the first instance dependent on the kind and form of salts introduced, the ratio of nitrogen and phosphoric acid in soil and their relation to other elements of the soil solution.

Nitrogen, introduced into the soil of river alluvium in different forms, was endowed with different action upon growth of plants and their store of alkaloids. Obviously poisoning effect, for instance, was produced by ammonium sulphate, and the plants died three days after it had been introduced at a ratio of 2 g per 2 kg soil.

Ammonium nitrate, while lowering the yield of vegetative mass by 30% in the second test and by 13% in the fourth one, has at the same time increased the content of alkaloids in the yield by 6 and 10% respectively, as compared to control. Potassium nitrate stimulated the growth of plants in all cases and thereby increased the store of alkaloids by 36% in the second test and by 106% in the fourth one, as compared to control. The cause of different action of nitrogen in the same soil lies above all in the difference between cations and anions of the soils introduced, which manifest their influence according to the degree of soil salinity. In acid medium the plant is known to assimilate the ammonium cation with greater ease than that of potassium. This results in abundant accumulation of ammonia in the plant, while the free acid residue acidifies the soil reducing its physico-chemical qualities. In this connexion we can admit that ammonia, so intensively storing in the plant when in acid medium, attains such amounts as to kill young and depress adult plants, which seems to have been a matter of fact in our experiments with sulphate and nitrate of ammonium. Good illustration thereby is afforded by potassium sulphate, which, introduced into the same soil and in similar quantity of salt, exerted almost a neutral action as against

the control. Another reason to account for the poisonous action of ammonium sulphate might possibly lie in the fact that the salt was introduced into soil in solution and at one bout. This might have resulted in notable rise of soil acidity and hence in acceleration of ammonia storing by the plant. What we have said here is not inconsistent with high efficiency of ammonium nitrate in red soil and sea alluvium. In the former the potassium nitrate more enhanced the yield per unit of pure nitrogen than ammonium nitrate did (by 30% of vegetative mass and 60% of alkaloids), whereas in the latter soil the ratio of nitrate nitrogen was nearly 19 times that of ammonia nitrogen. Phosphoric acid introduced into soil in the form of potassium or calcium phosphate promoted growth whatever the soil variety, but reduced the ratio of alkaloids in 3 cases, while in 2 cases (out of 6) this ratio went slightly up; thereby the average effectiveness per unit of nutritive substance was two and five times higher in the first salt with reference to vegetative mass and alkaloid ratios respectively. Similar result was obtained in the experiments of Lambert and Yersin with calcium phosphate, and this seems to be evidence of the negative rôle of calcium cation in the formation of alkaloid in cinchona. High efficiency of potassium salts (per se and, particularly, in mixture) should be put down to their physiological alkalinity, poverty of soils in nutriments indispensable for growth and development (nitrogen and phosphorus in the case of red soil, phosphorus or nitrogen alone in the case of sea and river alluvium respectively), as well as to the changed ratio between nitrogen and phosphorus in soil solution. 30 tons per ha of manure introduced into river alluvium increased the yield of vegetative mass by 47% and that of alkaloids by 96% compared to unmanured soils. The respective figures for poudrette, introduced at the ratio of 50 g per 2 kg soil, were 79—111% and 122—136%.

Conclusions: 1. Soil required by cinchona is that of slightly alkaline, nearly neutral reaction. Optimal reaction ranges between 7.3 and 8.0 pH. Soil acidity being reduced to 7.6 pH, the yield increased by 59% of vegetative mass and 50% of alkaloids.

2. Sulphate and nitrate of ammonium, being physiologically acid, inhibit growth in cinchona planted in slightly acid light argillaceous soil of river alluvium, while nitrate and phosphate of potassium act contrariwise, that is favour growth and formation of alkaloids.

3. Physiologically acid fertilizers are injurious for the culture of cinchona tree, if not preceded by lime in an acid soil, since in that case the yield is reduced chiefly owing to the deterioration of physical structure and chemical composition of soil.

4. The effectiveness of physiologically alkaline soils is above that of physiologically acid ones, when in acid soil, as the former better and the latter impair the physical structure and chemical composition of soil.

5. The same fertilizer has a different effect according not only to the reaction of soil and the form of salts introduced, but also to the ratio of nitrogen and phosphoric acid in the soil solution.

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PLANT EMBRYOLOGY

TWO NEW FORMS OF EMBRYO-SACK IN THE GENUS *TULIPA*

By I. D. ROMANOV

(Communicated by N. I. Vavilov, Member of the Academy, 11. XI. 1938)

In the previous note ([5]) we have announced the discovery of a new form of embryo-sack of the *Adoxa*-type in the genus *Tulipa*. Further investigation of species of *Tulipa* discovered another two forms of embryo-sack new for this genus: a normally 14-nucleate embryo-sack in *T. rosea* and a 5-nucleate in *T. Maximovicii*.

The development of the embryo-sack proceeds in these species, in the main, as follows.

T. rosea Vved. (Fig. 1,*a*). Up to the third division the development of the embryo-sack confirms the *Fritillaria*-form ([1]). After the two meiotic divisions the embryo-sack contains four nuclei arranged in a linear series; a migration of the one of the upper nuclei downwards takes subsequently place which results into the 1 + 3 arrangement of the nuclei. During the third division a material difference from *Fritillaria* becomes, however, apparent: all the nuclei divide autonomously and no fusion of the three lower nuclei takes place. An eight-nucleate embryo-sack is formed as a result; two nuclei are located in its upper part and six in the lower part. The middle of the embryo-sack is occupied with a large vacuole. After a certain period of rest a fourth division takes place. As a rule (i. e. in the majority of cases) two lower nuclei, out of the six chalazal ones, do not divide in the metaphaze of the fourth division and have an appearance of deeply-stained almost homogeneous droplets. This phenomenon is an expression of depression of the chalazal end of the embryo-sack, which is also expressed in different degrees in many other representatives of the group *Tulipeae* ([4]). The embryo-sack of *T. rosea* normally contains, therefore, after the fourth (and the last) division 14 nuclei. The mature embryo-sack contains a normal egg-apparatus, two polar nuclei and 9 cells in its lower part, two of which contain dark evidently dying nuclei*. The following aberrations from the above-described typical course of development were noted: 1) only one of the chalazal nuclei of the eight-nucleate embryo-sack does not divide, the mature embryo-sack containing 15 nuclei; 2) all the nuclei of the eight-nucleate embryo-sack divide which results in the production of a sixteen-nucleate embryo-sack.

T. Maximovicii Rgl. (Fig. 1, *b*). Up to the third division the development of the embryo-sack proceeds in this species according to the scheme of the *Fritillaria*-form. A remarkable peculiarity of this species consists,

* *T. Korolkovii* Rgl., a species most closely related to *T. rosea*, has embryo-sacks of the same sort.

however, in a very early depression of the chalazal portion of the embryo-sack which occurs as early as immediately after the second meiotic division. The depression is manifested morphologically in the fact that out of the four macrospore nuclei, one or two of the lower ones are somewhat smaller and possess denser nuclear reticulum as compared to the rest. After the microspore nuclei have assumed the 1 + 3 arrangement, the difference in the size of the chalazal nuclei becomes especially striking: one of them (the upper one) is usually of the same size as the micropylar nucleus, while the remaining two are considerably smaller. Sometimes two nuclei out of the three which compose the chalazal group appear to be rather large, while the remaining third (lowest) nucleus is small. During the prophase of the third division the chalazal nuclei lag very much behind the micropylar one in respect to passing prophase stages; namely, the small nuclei merely reach the early prophase stage, and sometimes remain altogether in the resting stage. During the metaphase of the third division the two lower chalazal nuclei, and often the upper chalazal nucleus, too, display a peculiar disorganized mitosis which is in the main characterized by the lack of normal chromosome formation: the chromatin appears to be scattered through the spindle in the form of irregular lumps or droplets*. In the telophase (even in such cases when the upper chalazal nucleus divides normally or nearly normally) only one nucleus of a very irregular shape is formed, for all the telophasic chromosome groups present in the chalazal portion are included into a common nuclear membrane. The micropylar nucleus always divides normally. The result of the third division is thus a three-nucleate embryo-sack. The fourth division is concerned only with the micropylar portion of the embryo-sack where a normal form of nuclei is formed. Toward the time of the fourth division the lower nucleus becomes somewhat rounded, more condensed and intensely stainable. The fourth division is the last one, so that the mature embryo-sack contains 5 nuclei: a normal egg-apparatus, one upper polar nucleus and one, evidently dying, nucleus in the chalazal portion.

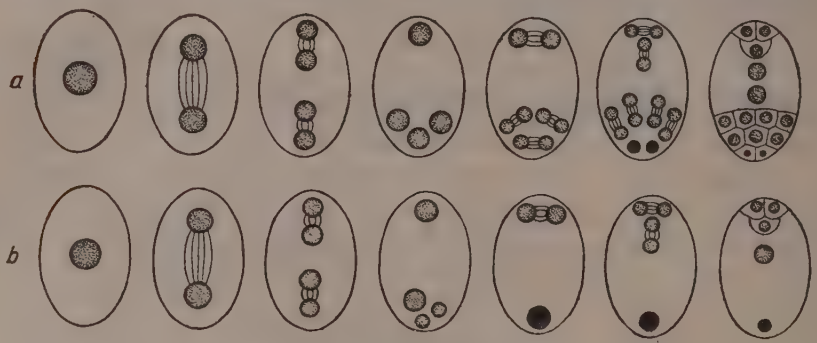

Fig. 1. Diagrams of development of the embryo-sacks: *a*, *Tulipa rosea*; *b*, *T. Maximovicii*.

The two forms of embryo-sacks described above, despite the strong difference between them, belong to the *Peperomia*-type (4 macrospores and 4 divisions). As regards the embryo-sack of *T. rosea*, it clearly belongs into the *Peperomia*-type, for we find there an abundance of nuclei which is in such a high measure characteristic of the classical examples of this type. The

* These anomalies of mitosis will constitute the subject of a separate paper.

embryo-sack of *T. rosea* is most closely related to those of *Tanacetum*, *Pyrethrum* (3) and especially *Majanthemum* (9). This embryo-sack is connected with the *Fritillaria*-form of the *Peperomia*-type, which is the basic and, probably, the most primitive form out of the whole group *Tulipeae*, by developmental aberrations (formation of eight-nucleate embryo-sacks with 2+6 nuclear arrangement), described in *Tulipa praecox* (2) and *Gagea lutea* (8). The embryo-sack of *T. Maximovicii* may be also easily brought into connexion with the *Fritillaria*-form, since in *Gagea capusii* which clearly belongs into the *Fritillaria*-form we similarly observe depression of the chalazal nuclei prior to third division, as well as anomalies during this division*.

The embryo-sack of *T. Maximovicii* thus represents a highly reduced form of the *Peperomia*-type. This new form undoubtedly is at the same time a connecting link between the *Fritillaria*-form and the *Clintonia*-form. In the light of the above data on the development of the embryo-sack in *T. Maximovicii* it appears quite obvious that the embryo-sack of *Clintonia* (7) is an ultimately reduced form of the *Peperomia*-type, in which the depression of the chalazal nucleus becomes apparent only after the heterotypic division. The problem on the place of the embryo-sack of *Clintonia* which was held by some to belong into the *Oenothera*-type (3) or was declared to be of dubious position (6) in the system of embryo-sack of *Angiospermae*, may be considered as finally solved.

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ENTWICKLUNGSMECHANIK

ÜBER DIE LOKALISATION DER FAKTOREN, WELCHE NORMALERWEISE DIE ANLAGE DER VORDEREXTREMITÄT DER AMPHIBIEN DETERMINIEREN

Von L. W. POLEŽAJEW

(Vorgelegt von N. V. Nassonow, Mitglied der Akademie, d. 28. X. 1938)

Die Frage nach den die Bildungsstelle der Extremitätenanlage bei Amphibien determinierenden Faktoren wurde von mir bereits früher untersucht (4). An die Stelle des entfernten Epithels und Mesoderms der Anlage der vorderen Extremität wurden das Epithel und Mesoderm der Seite transplantiert. Bei homoplastischen Transplantationen bildeten sich bei den Embryonen der Axolotl keine Extremitäten, bei den Embryonen der Tritonen dagegen entwickelten sie sich etwa in der Hälfte der Fälle. Auf Grund dieser Daten hielt ich es für wahrscheinlich, dass bei den Embryonen der Tritonen sich ausserhalb des Epithels und Mesoderms des Extremitätenseitengebiets ein die Bildungsstelle der Extremität determinierender Faktor befindet, wogegen er sich bei den Embryonen der Axolotl auf dem angegebenen Wege nicht feststellen lässt.

Ich habe diese Ansicht jedoch einer nochmaligen Durchsicht unterzogen. Als Veranlassung hierzu diente die bei der histologischen Untersuchung des Versuchsmaterials (Tritonembryonen) festgestellte Tatsache, nähmlich, dass die Extremität fehlt, wenn das Pronephros vollständig fehlt, sich jedoch bildet, wenn neben ihm auch nur 1—2—3 Pronephrosekanälchen verbleiben. Ich wollte daher vor allem aufklären, ob das Pronephros oder irgend ein anderer Faktor für die Determination der Anlagestelle der Extremität von Bedeutung ist.

Die Explantationsversuche der Anlagen der vorderen Extremitäten bei Tritonen (5) zeigen, dass für die Entwicklung der Extremität aus ihren Anlagematerial das Vorhandensein derartiger Teile der Anlage, wie die Axialorgane (Myotomen, Chorde, Nervenröhre), das Material der Ganglionarleiste (Pigmentzellen und möglicherweise das Corium), die peripherischen Nerven und Blutgefässe, nicht nötig ist. Ebenso ist das Vorhandensein des Entoderms nicht notwendig: die vorderen Extremitäten entwickeln sich an ihrem gewohnten Platz gut auch dann, wenn im Neurulastadium das ganze Entoderm des Embryo entfernt ist (3). Nicht notwending ist auch das Pronephros. Balinsky (1) entfernte das Pronephros bei Tritonembryonen im Stadium der frühen Schwanzknospe und trotzdem entwickelten sich die vorderen Extremitäten gut. Filatow (nicht veröffentlicht) konnte durch Transplantation des Pronephros unter das Epithel der Seite die Erscheinung der Induktion einer Extremität bei Axolotlembryonen nicht erhalten.

Ich führte Versuche der Entfernung und Transplantation des Pronephros bei Embryonen von *Pelodites caucasicus* aus und bestätigte die Ergebnisse von Balinsky und Filatow*.

Die angegebenen Tatsachen lassen annehmen, dass die Determination der Bildungsstelle der Anlage der vorderen Extremität bei den Amphibien in erster Linie mit den Eigenschaften des Extremitätseitengebiets des Embryonenkörpers und mit keinen in Bezug auf dasselbe äusseren Faktoren verknüpft ist. Alle diese Umstände veranlassten mich die untenstehenden Versuche durchzuführen.

Als Versuchsmaterial dienten Embryonen von Tritonen *(Triton taeniatus)* und Axolotln *(Amblystoma mexicanum)*. Die Operationen wurden im Stadium der Schwanzknospe unter sterillen Bedingungen ausgeführt. Die homoplastischen Versuche an Tritonen in der ersten und zweiten Serie wurden mittels Vitalfärbung durchgeführt. Auf die ungefärbten Embryonen wurden Teile von Embryonen, die in Nilblausulphatlösungen gefärbt waren, transplantiert. Täglich wurden Zeichnungen gemacht, welche die Lage des blauen Transplantats im Körper des ungefärbten Rezipienten angaben.

1. Transplantation des Seitenmaterials in das Extremitätengebiet ohne Entfernung des Pronephros. In dieser und der nächsten (²) Versuchsserie stellten wir uns zur Aufgabe die Aufklärung des Einflusses den die Extremitätenanlage umgebenden Gewebe auf das Transplantat-Seitenmaterial ausüben. Die Versuche wurden homoplastisch an Tritonembryonen durchgeführt. Nach Entfernung der Extremitätenanlage im Gebiet der 3—5 Somiten blieb ein Teil der vermutlich aktiven Gewebe seiner Umgebung zurück und zwar die Gewebe des Extremitätseitengebiets, die über dem Pronephros liegen; das Pronephros blieb gleichfalls am Ort. In das Gebiet der Wunde wurde ein in der Höhe der 6—10 Somiten genommenes Stück Seite transplantiert.

In allen 34 Fällen bildeten sich bei den Versuchstieren Extremitäten, die teilweise oder vollständig aus den Geweben des Transplantats bestanden. Diese Extremitäten waren im Vergleich mit den Kontrollexemplaren von kleinerem Ausmass, verspäteten häufig in der Entwicklung und waren häufig etwas nach hinten oder nach oben von der normalen Entwicklungsstelle der Extremität verschoben.

Die Einbeziehung der transplantierten Gewebe in den Entwicklungsprozess der Extremität kann man nur durch den Einfluss der Gewebe des Extremitätseitengebiets, die die Extremitätenanlage umgeben, erklären, nicht aber durch den Einfluss des an seiner gewohnten Stelle belassenen Pronephros (s. oben die Angaben über das Pronephros).

2. Transplantation des Seitenmaterials in das Gebiet der Extremität unter Entfernung des Pronephros. Diese Versuchsserie unterschied sich von der vorhergehenden nur dadurch, dass ein grösserer Teil der die Anlage umgehenden Gewebe mit der Extremitätenanlage entfernt wurde. Das Epithel und Mesoderm wurde in der Höhe der 3—5 Somiten zusammen mit dem Pronephros derart entfernt, dass der dorsale Rand der Wunde in der Höhe der Somiten lag. Die Wunde wurde mit einem Stück Seite bedeckt.

Von 22 erfolgreichen Operationen entwickelten sich nur in 5 Fällen Extremitäten (22.7%). Alle entwickelten sich atypisch: entweder fehlten die Finger, oder sie waren wesentlich kleiner als bei den Kontrollexemplaren, oder aber sie waren nach hinten verschoben und funktionierten nicht. In allen Fällen entwickelten sie sich teilweise oder vollständig aus den Geweben

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* Dieser Versuch wurde im Sommer 1937 auf der Stattlichen Embryologischen Station in Borshomi-Bakuriani (Grusien) durchgeführt.

des Transplantats. Die histologische Untersuchung ergab, dass, mit Ausnahme eines Falles, sich neben der Versuchsextremität ein Rest des Pronephros, 1—2—3 Kanälchen befand. Augenscheinlich war in diesen Fällen (im ganzen 4) nach der Extirpation der Extremitätenanlage doch noch ein Teil des aktiven Materials seiner Umgebung verblieben.

Die Ergebnisse dieser Versuchsserie lassen darauf schliessen, dass der Prozentsatz der Bildung von Extremitäten aus den Transplantaten der Seite stark herabgesetzt wird, wenn die Extremitätsanlage mitsamt ihrem dorsalen Teil, d. h. mit der Extremitätseitenumgebung und dem Pronephros, entfernt wird. Kürzlich veröffentlichte Balinsky (2) eine Arbeit, deren eine Versuchsserie mit der hier beschriebenen übereinstimmt. Wie er angibt, blieb in allen 7 Fällen nach der Transplantation des Seitenmaterials die Bildung einer Extremität aus. Auf anderem Wege konnte er jedoch zeigen, dass in dem die normale vordere Extremität umgebenden Gebiet Einflüsse vorhanden sind, die die Entwicklung der Extremität fördern. Somit stimmen die Angaben von Balinsky vollständig mit meinen Ergebnissen überein.

3. Transplantation des Seitenmaterials eines Tritons in das Extremitätengebiet eines Axolotls. Wie bereits erwähnt, rufen die homoplastischen Transplantationen des Epithels und Mesoderms der Seite in das Extremitätengebiet keine Extremitätenentwicklung bei den Embryonen der Axolotl hervor (4). Dies kann entweder von den Eigenschaften der Faktoren des die Extremitätenanlage umgebenden Gebiets, oder von den Eigenschaften des reagierenden Materials des Transplantats bedingt sein. Zwecks Prüfung dieser Möglichkeiten wurde ein xenoplastisches Experiment zwischen Embryonen von Tritonen und Axolotlen angestellt. Die Operation wurde ebenso durchgeführt, wie in der ersten Serie der vorliegenden Arbeit—das Pronephros mit den dasselbe bedeckenden Geweben wurde nach der Extirpation der Extremitätenanlage nicht entfernt, sondern es wurde xenoplastisch dem Axolotlembryo das von einem Tritonembryo genommene Seitenmaterial transplantiert.

In allen 24 Fällen war die Entwicklung der Versuchsextremität unterdrückt. Das die normale vordere Extremität des Axolotls umgebende Gebiet kann das Seitenmaterial des Tritonembryo nicht zur Entwicklung einer Extremität veranlassen.

4. Transplantation des Seitenmaterials des Axolotls in das Extremitätengebiet des Tritons. Die Operationen wurden ebenso ausgeführt, wie in der ersten und dritten Serie der vorliegenden Arbeit—das Pronephros mit den dasselbe bedeckenden Geweben wurde nicht mit der Extremitätenanlage entfernt. Als Donoren diente Axolotlembryonen, als Rezipienten — Tritonembryonen.

In keinen einzigen von 29 Fällen entwickelte sich eine Extremität aus den Geweben des Transplantats, was auf die niedriege Reaktionsfähigkeit dieser Gewebe hinweist. In 13 Fällen (44.8%) entwickelten sich Extremitäten aus den Geweben der Rezipienten (Tritonen). Diese Extremitäten waren in der Mehrzahl der Fälle verstümmelt und dem Ausmass nach kleiner als die Kontrollexemplare.

In der ersten Versuchsserie entwickelten sich bei den homoplastischen Transplantationen an Tritonen die Versuchsextremitäten in 100% der Fälle. In der vorliegenden (vierten) Versuchsserie entwickelten sich Extremitäten in 44.8% der Fälle. Der Unterschied in diesen Serien betrifft ausschliesslich die Bestandsverschiedenheit des reagierenden Materials: Seiten des Tritons und Seiten des Axolotls.

Schluss

1. Im Stadium der Schwanzknospe wurde den Tritonembryonen in das Extremitätengebiet homoplastisch das Material der Seite transplantiert. Es entwickelten sich vordere Extremitäten, die teilweise oder vollständig aus dem transplantierten Material bestanden. Folglich bestehen in dem die normale Extremitätenanlage umgebenden Gebiet Einflüsse, die die Entwicklung der Extremität fördern.

2. Offenbar können diese Einflüsse als Quelle nur das epitheliale-mesodermale Material des Extremitätseitengebiets haben und nicht etwa das Pronephros, Entoderma, die Myotome, das Nervensystem, die Blutgefässe oder irgend welche sonstige Teile des Embryokörpers. Bei Entfernung des dorsalen Teiles des Materials dieses Gebiets, das an die Extremitätenanlage stösst, verringert sich auch nach der Transplantation des Seitenmaterials der Prozentsatz der Bildung der Versuchsextremitäten sehr wesentlich (von 100% auf 22.7%).

3. Das Seitenmaterial der Axolotlembryonen kann an der Entwicklung der Extremitäten weder bei homo-, noch bei xenoplastischen Transplantationen (auf Tritonembryonen) in das Gebiet der vorderen Extremität Anteil nehmen. Offenbar besitzt es geringe Reaktionsfähigkeit. Das die Anlage der normalen vorderen Extremität des Axolotls umgebende Gebiet besitzt nicht die Fähigkeit, das Seitenmaterial der Axolotl- und Tritonembryonen zur Entwicklung in eine Extremität zu veranlassen. Offenbar ist der Einfluss dieses Gebiets bei den Axolotlembryonen schwächer, als bei den Tritonembryonen.

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Moskau.

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PALÉONTOLOGIE

SUR LA DÉCOUVERTE D'UN PARASITE ORIGINAL DES CRINOÏDES MARINS DU CARBONIFÈRE

Par N. N. JAKOVLEV, membre correspondant de l'Académie

Comme toujours, lorsqu'on a affaire à des matériaux fossiles, nous ne possédons que des traces du parasite déjà disparu.

Ces traces se révèlent dans notre cas sous forme d'ouvertures paires sur un côté de la partie inférieure des bras du crinoïde (fig. 1 et 2), entourées d'une élévation arrondie,—toute la formation rappelant les pores paires des cystoïdes. Ces pores paires se trouvent sur les différents exemplaires des crinoïdes *Cromyocrinus simplex* Trautsch* en nombre divers, correspondant apparemment à celui des individus du parasite sur le même hôte. Notamment, les trois exemplaires du crinoïde marqués par la présence du parasite en comptent de 2 à 4. La partie du bras marquée par leur présence est quelque peu enflée du côté où ils se trouvent, dilatée transversalement et de plus déformée—à surface devenue inégale (fig. 2—3) et ayant les articles vaguement limités; tout cela est indubitablement le résultat d'une réponse douloureuse du crinoïde à la présence et l'activité vitale du parasite.

Les ouvertures paires sont les orifices des canaux recourbés en forme d'arc, qui passent sur le côté du bras, de sa face dorsale à la ventrale, où ils s'ouvrent sur un côté du sillon ambulacraire: chaque canal aboutit à la base d'une pinnula, et comme les pinnulae ne se trouvent à chaque côté du bras que sur les articles d'ordre paire, les canaux sont disposés dans le même ordre, de sorte que les trois parasites correspondant aux 6 canaux (fig. 2—4) se supportent aux 12 articles du bras. Sur le bord de cet exemplaire se trouvent encore les restes d'un canal appartenant à un 4-me parasite. Comme nous l'avons déjà dit, les parasites se trouvent un peu au-dessus de la base des bras. Les parties inférieures des bras de ce crinoïde présentent une articulation mobile entre les articles, qui manque aux articles supérieurs**. Sur la fig. 1 le parasite inférieur se trouve deux ou trois articles au-dessus du dernier article mobile du bras. Sur les fig. 2—4 cet article mobile est le dernier article inférieur. Cet ainsi que le parasite, ayant choisi cette partie du bras qui est peu flexible, se trouve à l'abri des mouvements qui l'incommoderaient sûrement s'il était placé plus bas.

Revenant aux canaux, il faut dire qu'ils passent des pores à l'intérieur traversant toute l'épaisseur de l'article (fig. 5), se courbant en arc conformément à la paroi latérale de l'article et ont la forme d'un croissant, avec

* Provenant de la région de Moscou (collection du feu A. P. Ivanov).

** Ce point est éclairé dans le travail de l'auteur sur la faune des crinoïdes du Carbonifère de l'URSS qui doit apparaître prochainement.

le milieu plus large que les bouts; l'ouverture intérieure* du canal est plus large que l'extérieure. Comme nous l'avons dit, les canaux aboutissent aux bases des pinnulae, dont les articles principaux sont par conséquent hypertrophiés (fig. 3 et 4) et déformés. Les deux canaux entrent en contact avec les deux pinnulae voisines passant à côté de l'article du bras privé de pinnulae. Les pinnulae contiennent des produits sexuels, comme on le sait, dont s'alimentent quelques parasites des échinodermes. Ce phénomène a eu lieu apparemment dans le cas en question. Quoique le canal passant de la face extérieure du bras à la base des pinnulae est fermé sur toute l'étendue de sa coupe transversale, il ne faut pas croire qu'il ait reçu cette

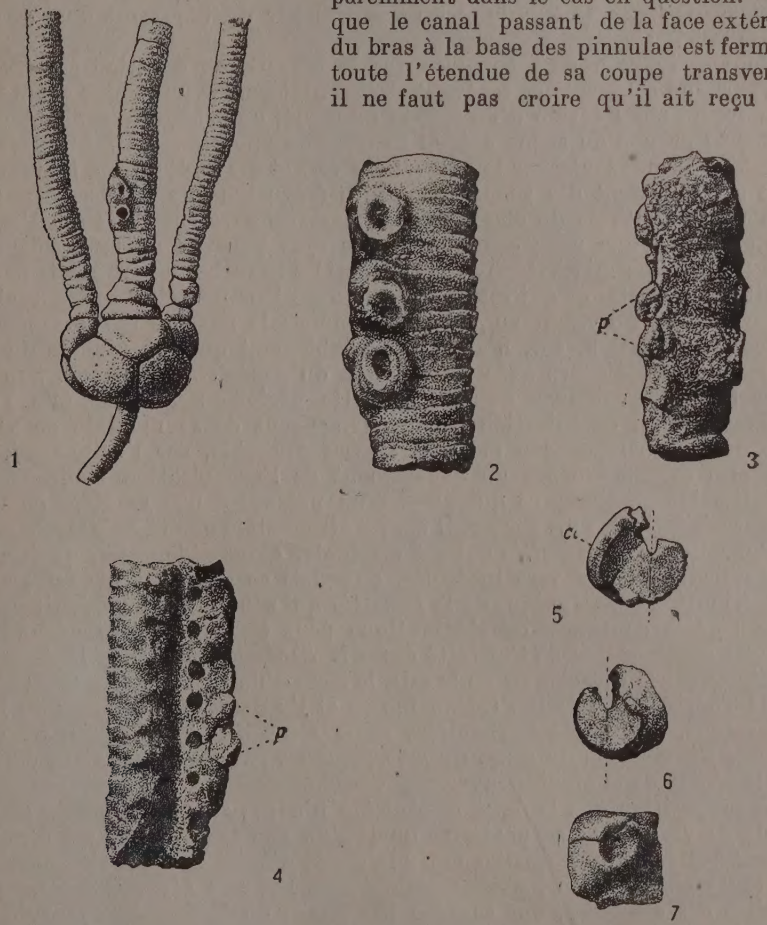

Fig. 1. *Cromyocrinus simplex* Trd. avec des parasites *Schizoproboscina Ivanovi* n. gen. n. sp. Le bras central porte deux parasites (dimensions naturelles).

Fig. 2—4. Une partie du bras d'un autre exemplaire du crinoïde portant 3 parasites (augmentée); 2—vue de côté; 3—vue du côté du sillon ambulacraire avec six ouvertures des canaux du parasite sur le côté droit; 4—vue de côté, bras à articulation disparaissante. Fig. 3 et 4: *p*—articles principaux voisins des pinnulae en déformation.

Fig. 5—7. Débris du bras d'un troisième exemplaire du crinoïde avec un parasite; 5—fracture le long de la fente passant à travers le canal *C*; 7—vue du côté extérieur; 6—vue du bout opposé à la fente; à droite—un amassement de la substance squelettique, produite par le parasite.

* Près du sillon ambulacraire.

forme par suite d'un perçage du bras. Dans la coupe transversale de l'article le canal se trouve un peu en dehors des limites de la coupe, si nous en reconstituons les contours normaux, décomposés par la déformation (fig. 5—6). Il paraît plausible que s'était un canal ouvert en forme de sillon qui se formait d'abord par l'action corrosive de l'organe tubulaire mou du parasite touchant la paroi latérale de l'article, mais la sécrétion d'une substance solide à la suite d'une réaction de l'organisme du crinoïde sur l'irritation produite par le parasite a entraîné un enveloppement du côté extérieur de l'organe tubulaire du parasite par un tégument dur, de sorte que le canal s'est fermé.

Nous arrivons donc à conclure que le parasite en question est parasite extérieur, un ectoparasite, recevant l'alimentation par un double canal tubulaire, formé par l'action d'un organe bifurqué, un proboscis, probablement.

A quel groupe du règne animal ce parasite appartenait-il? Les parasites des échinodermes sont pour la plupart des vers et des mollusques, les premiers étant généralement des zooparasites plus fréquents que les derniers. Dans notre cas l'hypothèse du classement du parasite parmi les vers est d'autant plus probable que nous connaissons des vers pourvus de proboscis: telle est la *Bonellia* parmi les Géphyrées chez qui les branches du proboscis portent des sillons ouverts, ce qui est en rapport avec leur nourriture planctonique. Le parasite en question, auquel nous donnons le nom de *Schizoproboscina Ivanovi* nov. gen. n. sp., n'existait probablement qu'à la periode du Carbonifère et était disparu avec l'extinction du genre *Cromyocrinus*. Son existence fut-elle prolongée au-delà de cette période après quelques modifications de son organisation et un changement de sa manière de vivre? Cette dernière supposition me paraît assez probable, car l'ectoparasitisme peut être caracterisé par un changement de l'organisation modérée, une spécialisation médiocre ce qui permet un passage à une manière de vivre non-parasitique. Et plus encore, il me paraît possible que la *Schizoproboscina* fut l'ancêtre de la *Bonellia* qui est originale, étant sédentaire, quoiqu'elle n'appartient pas aux vers tubicoles, auxquels ce genre de vie est propre. La distribution géographique de la *Bonellia* qui n'habite que la Méditerranée et les parties contiguës de l'Atlantique peut être considérée comme une nouvelle confirmation de l'affinité entre la *Schizobroboscina* et la *Bonellia*. La Méditerranée est, comme on le sait, le reste d'un bassin marin très ancien, appelé Thétis, qui reliait l'Océan Indien et l'Atlantique au temps du Haut Paléozoïque. Le bassin Carbonifère russe était lié avec Thétis, de sorte qu'après l'extinction du genre *Cromyocrinus* les parasites pouvaient émigrer dans la région de la Méditerranée.

La supposition que la *Schizoproboscina* n'a pas subi l'extinction et continuait de vivre dans sa postérité quoiqu'un peu transformée est d'autant plus naturelle que les parasites ont une durée d'existence générique embrassant toute une série de périodes géologiques. Les vers *Myzostomidae*, autres parasites des crinoïdes, ont survécu des temps du Carbonifère jusqu'à nos jours. Les zoologistes ont constaté que les espèces des hôtes liées par une affinité quoique habitant loin l'une de l'autre (quelques espèces de grenouilles, par exemple, n'habitant que l'Amérique du Sud et l'Australie) ont de parasites protozoaires semblables et même presque identiques au point de vue de l'espèce (*Zelleriella* des *Opalinidae*); ces parasites ne se rencontrent que dans les mêmes localités, de sorte qu'ils servent de preuve pour admettre que c'étaient toujours seulement les pays du Sud où ces grenouilles étaient répandues en se propageant, dans une époque lointaine, d'un des continents mentionnés sur l'autre par une voie méridionale inconnue.

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